IN THE UNITED STATES DISTRICT COURT

FOR THE NORTHERN DISTRICT OF OKLAHOMA

STATE OF OKLAHOMA, ex rel. W.A. DREW EDMONDSON, in his capacity as ATTORNEY GENERAL OF THE STATE OF OKLAHOMA, et al.	)	
Plaintiffs,	)	
vs.	)	CASE NO. 05-329-GKF-PJC
TYSON FOODS, INC., et al.,	)	
Defendants.	)	

TRANSCRIPT OF NONJURY TRIAL PROCEEDINGS
JANUARY 11, 2010
BEFORE GREGORY K. FRIZZELL, U.S. DISTRICT JUDGE
VOLUME 91, P.M. SESSION

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JANUARY 11, 2010:

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THE COURT: Good afternoon, Mr. George.

MR. GEORGE: Good afternoon, Your Honor. We have a new witness on the stand. Would you like to ask him the first questions you traditionally do?

THE COURT: Let me -- before we begin with the new witness, let me just ask plaintiff's counsel here real briefly, we were going to finish up with one of the witnesses that the defendants called live. You were going to call him live. Is that going to be in rebuttal?

MR. BULLOCK: No, I think the plan is -- Mr. Nance isn't here, he's been working with Mr. McDaniel. I think there's arrangements for him to be put on on Thursday morning.

THE COURT: So that's six witnesses.

MR. BULLOCK: No, I got it wrong.

MR. MCDANIEL: If I might, Your Honor. Mr. Nance and I did talk today, and Mr. Thompson, Steve Thompson is available tomorrow. So the plan is, assuming that Dr. Dicks resumes his cross and is finished today, we will -- the State can put Mr. Thompson on the stand after Dr. Sullivan. So we

anticipate that being tomorrow morning sometime, depending the length of cross.

THE COURT: But that will be six witnesses, not five. Mr. Green had mentioned four. Then we've got Peach, then we've got Thompson. So that's six witnesses. We're not going to finish it this week, gentlemen, and then get into rebuttal. It's far too ambitious.

Mr. George, let me ask the witness to raise his right hand to be sworn, please.

(Witness sworn.)

THE COURT: State your full name for the record, please.

THE WITNESS: Timothy Joseph Sullivan.

THE COURT: Mr. George, you may inquire.

MR. GEORGE: Thank you, Your Honor.

DR. TIMOTHY SULLIVAN,

having been first duly sworn, was called as a witness and testified as follows:

DIRECT EXAMINATION

BY MR. GEORGE:

Q. Dr. Sullivan, before we get too far, I want to make sure the record is clear as to who you are. You're not a the stunt double for Dr. Dicks; is that right?

A. That's correct.
Q. Doctor, where do you hail from? What's your home town?
A. Corvallis, Oregon.
Q. Are you employed?
A. Yes.
Q. Who are you employed with?
A. E&S Environmental Chemistry, Inc.
Q. What is your current position with that firm?
A. I'm the president of E&S.
Q. And when did you join E&S?
A. I cofounded it in 1988.
Q. Doctor, do you hold any educational degrees?
A. Yes.
Q. Could you provide the court with a brief summary of what degrees you have obtained, what they're in, and what from institutions.
A. A bachelor's in history with a minor in education from Stonehill College. Master's in biology from Western State College of Colorado. Ph.D. from Oregon State University, and it was a multidisciplinary Ph.D. in biological sciences with three areas of emphasis rather than the standard one, and those areas were ecology, zoology and environmental chemistry.

Q. Doctor, how does a young man go from a BA in history to a Ph.D. in biological science?
A. It's a tortuous path. After obtaining my BA in history, I changed my plans from being a history teacher and coach to pursuing sciences, and that involved taking a number of courses to make up for undergraduate deficiencies in the sciences. So I did that over a number of years while working. But, actually, I found that the background in history has been enormously helpful for me in my career because of some of the things I learned in history rather than science.

THE COURT: I was going to say, you're not implying that a bachelor's in history is a deficient education?

MR. GEORGE: That's where we were going next.

THE WITNESS: I should not imply that at all, Your Honor. I apologize if it sounded that way. But in terms -- sciences have such a core of classes that must be taken in any natural science, that it's a rather full schedule.

Q. (By Mr. George) Doctor, did the realization of what history teachers make have anything to do with your changing your degree?

A. I don't believe it did, actually.
Q. Okay. Doctor, you mentioned that you have a Ph.D. Did you complete a dissertation to obtain that?
A. Yes.
Q. Could you describe the topic or the subject matter of your dissertation?
A. It was on the production and fate of a class of chemicals called polycyclic aromatic hydrocarbons, some of which are carcinogenic, or cancer causing.
Q. How long did you work on the completion of your Ph.D.?
A. It was a five-year program between the coursework and doing the research for my dissertation.
Q. Was there a particular industry that was involved in your Ph.D. work?
A. It was the forestry industry. The study that I did for my dissertation had to do with the production and fate of these compounds on slash burn sites in the mountains. After logging, the logging companies will often burn the remainder of the woody material on site, and that helps to promote a better regrowth of a replanted forest.
Q. As part of your Ph.D. work, did you study the

movement of those constituents through water pathways?

A. Yes. The primary focus was on the production and then the movement from the area that was burned, which is the duff layer of the forest down into the various layers of the forest soil. Then an additional component of what I did was to look at movement of those chemicals into streams that were -- ran through the sites.

Q. Doctor, what did you do after you obtained your Ph.D. in terms of work?

A. Well, the first thing I had to do was make some money because I was quite broke at that point, so I went back to construction, did that for a period of probably six or eight months, had a small painting and drywall business.

And then I did some more teaching. I had done teaching prior to that on a couple of occasions. I taught for half a year at the school where I had earned my master's degree. One of my professors there had taken ill and was not able to complete his courses, and they asked me to come and take over his coursework for the rest of the year, which I did.

Q. Doctor, where were you employed next after you

obtained your Ph.D., laying aside the construction and teaching?

A. At that time, I was busy applying for what's called postdocs, postdoctoral research, associate physicians in various places. And I obtained a postdoc in Norway -- in Oslo, Norway and spent two years working there.

Q. What type of work were you involved in, in your postdoc in Norway?

A. I would characterize it mostly as aluminum biogeochemistry with a major focus on hydrological flow paths in watersheds, movement of various chemicals, primarily aluminum, but other chemicals as well, through the watershed system.

Q. Doctor, did you do any work in connection with that postdoc research that would be fairly described as storm chasing?

A. I did quite a lot of storm chasing. Took thousands of samples of streams, occasionally lakes, precipitation, throughfall in the forest, snow pack samples.

Q. Doctor, after you completed your postdoc research, did you take employment somewhere?

A. Yes. I worked at for two years at the Environmental Protection Agency research laboratory

in Corvallis, Oregon.
Q. What did you do, or what type of work did you focus on in your two years at the U.S. EPA research lab?
A. I was hired primarily to publish the results of some rather large water surveys that had just been conducted, what's called the Eastern Lake Survey and the Western Lake Survey. And combined, they called it the National Lake Survey at that time.
The EPA had sampled thousands of lakes and also streams, but my focus at that point was on the lakes. Selected that using a randomized process throughout the United States. It was part of what was called the National Acid Precipitation Assessment Program . It was the U.S. National Acid Rain Program.
Q. Would you describe that as a large research project?
A. At the time, it was the largest environmental research program ever conducted anywhere in the world. It was ten years and half a billion dollars. It's been surpassed many fold by climate change and perhaps some other programs since then, but at that time, that's what it was.
Q. Doctor, I believe you mentioned that part of

your work was the -- encouraging publication as a -- with respect to the data that came from that research; is that right?

A. Correct. The samples had been collected, laboratory work done, databases built, some reports prepared. And then the next step was to get those results into the open scientific peer-reviewed literature to share as much as possible that information with other scientists in the United States and elsewhere. So I was hired to come in and work with analyzing the data, helping to evaluate what kinds of publications should be written, analyzing the data, writing the publications and getting them out.

Q. Were you successful in getting the peer-reviewed literature populated, if you will, with data and analysis from that research program?

A. Yes. There were quite a few publications that came out of that.

Q. Let's talk about your current employment with E&S Environmental. Can you provide the court with an overview of the type of work and projects that you have been involved in at E&S?

A. It's a wide diversity of projects. I would say the main focus over the past 20-plus years has been

on water quality issues, on the influence of different stressors on water quality, in particular, acidifying substances, nutrients, fecal indicator bacteria, stream temperature, some of those kinds of things.

A lot of work on looking at the connections between human activities and the quality of water, and those activities would include agriculture, especially livestock operations, forestry, urban development, rural residential housing impacts, those kinds of things.

I've also done quite a lot of work in terms of environmental restoration, on-the-ground restoration projects. A lot of work with synthesis and integration of environmental data, multidisciplinary data that makes some sense of the overview of what the data have to tell. And a lot of work related to that on watershed assessments where we would go in and evaluate the various issues in the watershed and the stressors there.

Q. Doctor, you used a term "multidisciplinary." Do you consider your work to be multidisciplinary?

A. Very much so.

Q. For the benefit of the record, could you provide an explanation of what you mean by that?

A. It means dealing with multiple disciplines and multiple media. So for example, the world I live in, my research world is a lot of biology and a lot of chemistry, but there's also quite of bit of soils, hydrology, sometimes some geology. Fisheries and wildlife issues come into it, a lot of work with vegetation, and then a lot of work with the water of chemistry. My work on the effects of various pollutants on lakes, streams, soils, forests and other types of vegetation.

Q. Doctor, do you bring this multidisciplinary approach to any of your current work?

A. Yes. I think that some of the projects that I'm involved with now where I'm the project manager and/or a co-principal investigator illustrate a variety of projects.

Q. Doctor, are any of those projects projects on which you're working for federal environmental agencies?

A. Yes, very many of them are.

Q. Could you pick out a handful of current projects where you're working with the federal government that would illustrate the multidisciplinary nature of your work, and provide a little description as to those projects.

A. Okay. For the National Park Service, I'm in the middle of a project we call the nitrogen screening project. And what that involves is there are 273 -- 272 national parks throughout the country that they call inventory monitoring parks, those are all the major parks, that are grouped into 32 networks, park networks. And so this is a study to prioritize and rank all of the networks from 1 to 32 and all the parks from 1 to 272 in terms of their vulnerability to being damaged by nitrogen input from outside the watershed.

And that's nitrogen input -- and the component of that would be nutrient enrichment eutrophication kinds of environmental effects. So what we're doing is we're evaluating a number of source terms of nitrogen pollution, we're evaluating a number of terms that reflect the sensitivity of the parks to being damaged by nutrient enrichment aspects. And that includes the distribution of vegetation types. Some types are far more sensitive to those kinds of effects than others. So we tabulate and quantify and map how much of these various types of vegetation that are most sensitive are present in the various parks.

We also map and tabulate the locations of

high elevation lakes, which are often nitrogen limited rather than P limited, as we're dealing with in this case. So we're trying to identify the locations of the lakes that are likely to be most sensitive to that kind of damage.

Q. Doctor, what federal agencies are you working with currently other than the Forest Service?

A. Well, that one was the Park Service.

Q. I'm sorry, the Park Service.

A. Forest Service is a good example. I'll give you one for the Forest Service. I'm a project manager of developing protocols -- nationwide protocols for the Forest Service Air Program. So this would be -- the different offices of the Forest Service, when they're involved in environmental sampling, they collect the data using whatever methods, and it's not standardized, and that's problematic.

So they've asked us to establish protocols in five areas. One is lake and stream sampling protocols. The second one is laboratory analysis protocols. Quality assurance, quality control protocols, data analysis protocols, and then some biological protocols that have to do with benthic invertebrates in streams and zooplankton in lakes.

Q. Do you have any current projects ongoing with the Environmental Protection Agency?
A. Yes, a couple. One example would be as part of the new National Lake Survey which was conducted in the summer of 2007, I'm still involved in some work on that. And what that entails is that was a statistical or a random-based sampling of over a thousand lakes around the country from looking at responses of lakes to a number of different kinds of stressors.

And the statistical design is important because that allows them to make estimates across all lakes in the entire country, what percentage of the lakes do this or are like that, for example.

But what it doesn't tell is what the background or reference conditions might be or what might be an achievable goal and for different chemical and biological parameters in those lakes. So there's a desire by EPA to sample other lakes to try to find relatively pristine sites and call them reference lakes that they can compare the results of the statistical sampling to.

We were hired in working with collaboration with scientists from Oregon State University to help them to do that, to evaluate available data in a

number of regions around the country in terms of the chemistry, looking at aerial photos, land use, land cover to identify groups of candidates.

So we would tell the agency, if you want to find candidate reference lakes in the northeastern United States, this is our list of the ones based on the information we have that we think are your best bet.

The reason that's important is because if they go out and search haphazardly and they're spending $20,000 apiece to do these lakes, and they turn out not being referenced and not part of the statistical part, they can't use the information. So it's about helping them to save money by giving them a tool that will better enable them to find reference lakes in the various regions.

Q. Doctor, are you presently involved in any work around something that's called critical loads?

A. Yes.

Q. Could you describe that briefly?

A. Yes. I have a number of projects on critical load. The critical load is the level of pollution above which ecosystem damage is expected. And the flip side is, if the pollution levels are high, is how low do you need to reduce the pollution so that

you can allow a resource for recovery. So that's a critical load.

And there are different ways to estimate or calculate those. And they're based on models. And we have a number of projects throughout the eastern United States on calculating those critical loads.

Q. Who would be your client in those critical load projects?

A. We have one that's called the multiagency critical loads project. We have funding in that project and a cooperative arrangement with Park Service EPA and Forest Service. USGS is also involved.

I have another critical loads project for the New York State Energy Research and Development Authority. So that's a state project rather than a federal project, and that's on critical loads, too.

Q. Doctor, you mentioned, I believe, briefly earlier that you had done some environmental restoration work.

A. Yes.

Q. Do you recall that? In addition to E&S Environmental, do you have a business called E&S Restoration?

A. It's called E&S Environmental Restoration,

Inc. A business I started in 1996.
Q. Can you describe briefly the type of work and projects in which you have been personally involved as a result of that business.
A. That business has focused on on-the-ground restoration projects. It's a very small company. It's not a major component of what I do.

On-the-ground restoration projects, a number of them have been on agricultural lands that have cattle operations, especially dairy farms.

We've also been involved in implementation of Best Management Practices of a variety of sorts on agricultural lands and on forestlands. They involve things like erosion control, streambank stabilization, invasive weed identification and eradication, fencing cattle out of streams, providing offstream watering for cattle, planting native plants in riparian buffers, modifying roads and culverts to accomplish various objectives like minimizing flooding of ag lands that cause pollution issues, decommissioning logging roads to put them back into vegetative communities.

So a variety of different kinds of on-the-ground projects. Then we also produce native grass seed that we provide to the federal government

for restoration work.
Q. Doctor, if I might, could I suggest that you slow down just a tad. I can tell you're excited about what you do. The court reporter, I've noticed her grimace a time or two in trying to keep up. I'll try to be more measured in my pace as well.
Doctor, we've identified some of the federal agency clients that you have worked for. Have you also worked for environmental stakeholder groups?
A. Yes, quite a few. I guess the best example is watershed councils. I've worked for probably about eight or ten watershed councils, and those projects have mostly been focused on constructing watershed assessments and watershed analyses.
The other stakeholder group that I've worked with quite a lot is called the Southern Appalachian Mountain Initiative. That was on a project on a piece of real estate that extended from Virginia and West Virginia in the north to Georgia and South Carolina in the south on the Appalachian Mountains. That was a model-based project of acidification responsive streams.
Q. Doctor, obviously you're in that chair today because we have a lawsuit. And your services in

this case are provided in connection with a lawsuit. What percentage of your professional work over the last, let's say, 20 years has been comprised of working with lawyers in connection with litigation?

A. Well, if I take out this never-ending log case I'm involved in right now, I'm sure it's less than five percent. It's quite small. Then over more recent years, maybe 10 percent, something like that.

Q. Doctor, have you published the results of any of your scientific work in the peer-reviewed literature?

A. Yes.

Q. Could you provide the court with a brief overview as to the scope and the magnitude of your publication history.

A. About a hundred peer-reviewed publications, roughly including, some books and book chapters, a lot of scientific journal articles, Encyclopedia of Water entry, a variety of different things.

Q. Doctor, we may have touched on this a little bit with some of the questions about your projects, but let me ask this directly. What experience do you have with regard to evaluating the likelihood of pollutant transport to surface waters in watersheds?

A. I've done that in a number of projects in various ways. I guess I could start with the earliest one. That would be some of the work in Norway. What we did is that work on biogeochemistry was focused quite a lot on water flow paths and changes in water flow paths during what we call hydrological events, and those are rainstorms and snow melt and rain on snow events.

So what that involved was looking at the changes in the chemistry of drainage water, starting with the precipitation coming in, the rain and the snow, and then looking at how the chemistry of that changed as it moved through the soil system.

So we could collect samples of soil water at different layers in the soil profile during the storms. We would collect samples of throughfall where the rain goes through the foliage in the forest. That changes the chemistry of the water. We would analyze that.

We would collect samples of the stream and analyze that. Samples of the snow pack. So looking at different parts of the system and changes in the hydrology as you move through the system and how that impacts the chemistry, that was a rather significant component of my postdoctoral research.

That would be the first one.

Another project that I did that was pretty heavily focused on movement of chemicals or constituents to streams would be a project to look at the effectiveness of riparian buffers in agricultural lands, on pasture settings. And that project, I set up I think it was 23 treatment cells on pasture lands. Each was about a hundred feet long and about maybe 15 feet wide. And we would apply dairy cow manure to those plots, and they had -- they were in different slope classes and they had different sizes of riparian buffers installed, and then we would be build gutter systems to collect the runoff as overland flow and shallow groundwater interflow. So to collect that surface -- those two surface layers of runoff because those were the layers of hydrological flow that would contribute the constituent that we were concerned about into a stream. It was fecal coliform bacteria that we were focused on in that study. So there was a lot of that kind of effort there. I can talk about other examples, if you like.

Q. Doctor, let me ask you about one specifically that I don't think you have discussed yet. Have you been involved in the Tillamook Bay Watershed?

A. Yes.
Q. What type of work have you done in the Tillamook Bay?
A. I worked on the Tillamook system for about eight years, and that involved a variety of projects. We did several watershed assessments there. But a lot -- we did a characterization study. The bay has five rivers that flow into it. There are big concerns there about salmonid fisheries issues and about fecal indicator bacteria getting to the bay where the oyster beds are, people consume raw oysters, there is some health concerns about that.

They're also concerned about riparian vegetation integrity and water temperature that is associated with that and erosional issues and also nutrient issues. So a number of concerns.

We did a characterization study for a year where we sampled throughout different parts of the watershed and made an evaluation and assessment of what the chemistry was in each of the five rivers. And as those rivers came out of the forest at what we called the forest/ag interface, then as you moved down through the agricultural lands, then we had some urban lands and then the bay.

So we looked at data from the forest/ag interface to reflect what was happening up in the forest, and we looked at data just above the bay to see what the intervening impacts were from the ag lands and the urban lands.

So we did that characterization study. Then we did episodic projects where we sampled during storms. I can't remember how many storms we did, but it was a lot over about five or six years. We would go out and sample repeatedly during a storm and evaluate changes in the chemistry, the stream water during that storm. And the big focus of that part was on the fecal indicator bacteria.

We also did a demonstration project. I can talk about that one, if you'd like.

Q. In your Tillamook Bay Watershed assessment work, did -- you described your sampling efforts -- did you bracket suspected sources in your sampling?

A. That was another actually couple of projects that we did in Tillamook was a bracketing-type project.

In that, what we did -- I'll talk about two because that was really my major focus, two of the rivers. What we did was to sample from the forest/ag interface down into the bay and actually

into the bay itself at multiple intervals. Depending on the river, there were maybe 12 to 20 different locations along the river where we would sample. And we would sample during storm events. And we would sample at three locations in the middle of the river and on the right and left sides of the river so we could evaluate things coming in from the sides.

So we would collect these samples and then evaluate as you move downstream at what location did the concentration of bacteria jump up. Because if the concentration of bacteria jumps up at that location, especially if it happens repeatedly in lots of storms and during different samplings during the storm, then we would suspect that there's something in that landscape between those two points that's contributing bacteria.

So then we would identify all the land that would drain into that reach of river, and we would look at the land cover issues, we would tabulate the housing clusters to evaluate septic system issues, and then try to establish relationships between the various pieces of real estate draining into the slices and what the changes in fecal bacteria were. So that was a way to get at the sources of fecal

indicator bacteria.
Q. Doctor, in that assessment work, were you assessing potential nonpoint sources?
A. Yes. We had some point source -- we had three point sources in the watershed. That was primarily a nonpoint source project.
Q. Doctor, in your professional experience in assessing potential nonpoint sources, is it helpful to have the sort of localized sampling approach that you've described?
A. It's critical. Nonpoint source, by definition, is a local issue. It's a distributed pollutant. If you're not collecting information that's site-specific and narrowly focused, it's very, very difficult to figure out what's going on.
Q. I'm going to go back for just a moment. You described this project involving -- I think you described it as a demonstration project where there was some plot studies done. Do you recall that testimony?
A. Those were actually two projects, but yes.
Q. I'm interested in the study where you were actually evaluating in the field the movement of constituents off of a pasture.
A. Okay.

Q. How would you describe that project? Give me a term to use.
A. That would be an experimental buffer effectiveness project.
Q. Was that a natural rainfall study?
A. Yes, it was.
Q. I'm interested in how you collected the flow that you were analyzing in those studies. Could you describe that briefly and keep your pace slow. You're speeding up again.
A. Sorry. The more I like the project, the faster I go. So you can gauge which projects I like better than others.

So what we did was we built a metal gutter system to install at the base of each of our plots. So we dug it two foot or more -- about two and a half deep trench and then installed this buffer -- I'm sorry, installed this gutter. And what the gutter consisted of was a piece of metal that would slide into the soil profile that would allow us to capture that shallow interflow as well as the overland flow over the top on the pasture vegetation.

And then the water that came over the edge and through that shallow interflow would then flow

down into the gutter. And the gutter was divided into various compartments, each of which was connected by a tube to a collection bottle.

And so during the course of a rainstorm, we would go out typically multiple times and we would collect the samples and then take them immediately to a laboratory and analyze them for bacteria.

Q. Doctor, you described that project as an assessment of overland flow. Have any of the other projects that -- it may be some that we already discussed -- fall into that category of professional work in assessing overland flow?

A. Yes. Overland flow is a pretty important part of the demonstration project, so I want to come back to that. But overland flow is also a component of what we did in the Norwegian research where we were identifying locations in the watershed where most of that work was focused where we did have some overland flow, and it was overland flow of a particular type where the groundwater table would rise up to the point where when it would rain or the snow would melt, there was nowhere for the water to go, so it would flow over the surface.

At that time, I don't think people were using the terms that are being used now. That's an

infiltration excess overland flow. I don't think that term even existed. But we were looking at that same mechanism at that time.

But the other project where I've done quite a bit of work with overland flow issues was the demonstration project, also in Tillamook. That was working with farmers on implementing BMPs on their pastureland. I could talk about that one, if you'd like.

Q. Briefly, how did you evaluate overland flow considerations in that work?

A. In that work, what we did was to target places where we had overland flow and try to remediate those, because the main focus of that effort was to quantify and to demonstrate improvement in bacterial conditions in the stream in response to implementation of Best Management Practices.

There were other issues that we were concerned about, too: Total suspended solids and temperature, for example. But bacteria was the main one.

We identified places where overland flow occurred, and then we tried to fix those areas.

Q. Doctor, let's turn to your work in the present project, this lawsuit. What was your charge in this

case, if you were given one?
A. I think I was given multiple charges. By far, the most important one, in my view at least, was to evaluate the information that was put forth by the experts from the plaintiffs. So I was asked to evaluate what they had done, their data, their reports, and provide response -- evaluate those and respond to them.

The other things that I was asked to do, early on, I and my company played a major role in pulling together the data because we didn't know really what was going on with this new watershed to us, and I think new watershed to many of the attorneys and other experts as well.

So we pulled together data, landscape data, GIS databases that would be used to evaluate the watershed, a number of those. And then we also pulled together existing stream and lake data. It was not an exhaustive search, but it was a search to get enough data to look at the patterns and to be able to communicate to the other experts on our team and to the lawyers on our team what the water quality issues were and what things looked like. So we did quite a lot of that.
Q. Doctor --

A. I think those were my major charges.
Q. Were you asked to evaluate the central tendencies in any of the water quality data?
A. Yes. I remember we generated a lot of plots of medians and quartiles, box-and-whisker plots of concentrations of this and that in various media for the data that were collected by the State. So that was further into the case where the State provided data that we were able to look at. And we did a lot of that summary statistic work, again, to provide to the other folks involved in the team to show them what the data looked like.
Q. Dr. Sullivan, in addition to the water quality data that we've been discussing, what other materials did you review in preparing your opinions for this case?
A. Well, I reviewed a lot of reports on both sides of the case. I think I reviewed most or all of what we might call the effects reports. I reviewed deposition testimony, again, from many experts on both sides. I reviewed trial testimony from many experts on both sides.
Q. Doctor, with respect to the water quality data, did you limit your review to the data that was produced by the State's consultants in this case?

A. No.
Q. What other sources of water quality data did you consult for your analysis?
A. I took a look at some national scale studies for water quality data so we'd have some perspective of what the water chemistry in the IRW looked like in comparison to the country at large and other portions of the country. I also looked at some Oklahoma-specific data.
Q. Doctor, did you retrieve and evaluate any data from the United States Geological Survey?
A. Yes.
Q. Did you retrieve and evaluate any data from the U.S. EPA?
A. Yes.
Q. Okay. Is there a database -- a water quality database that's maintained by the EPA?
A. Yes. They maintain a database that's called STORET. It's not necessarily samples that were collected and analyzed by the EPA, but it's a very large database that people commonly will go to to get an idea of what the patterns are in water quality data.
Q. As part of your work in this case, did you evaluate any land use data?

A. Yes.
Q. Can you provide the court and the record with the sum indication of what type of land use data you looked at?
A. Well, we used primarily the National Land Cover Dataset, which is the primary dataset for the United States to look at land cover issues.

I think that in terms of land cover, that would be the main one.
Q. Doctor, were you provided any information in connection with your work in this case regarding livestock populations or human populations?
A. Yes. We looked at human populations from the U.S. Census primarily. We looked at livestock populations from the Ag census. Yeah.
Q. Doctor, let's turn to the substantive aspects of your testimony, and let's start with your review of phosphorus data. Did you review any phosphorus water quality data from watersheds outside of the Illinois River Watershed?
A. Yes.
Q. Okay. And you have, as part of your work in this case, reviewed some of the testimony from some of the State's experts that have occurred in this trial, have you not?

A. That's correct.
Q. Did you review Dr. Stevenson's testimony?
A. Yes.
Q. Do you recall that Dr. Stevenson suggested that the phosphorus levels in the Illinois River Watershed in the receiving waters were elevated as compared to phosphorus levels elsewhere?
A. Yes, I remember that.
Q. Do you agree with that testimony?
A. No. I think that it all depends on where you look. There are certainly streams and rivers around the country that have higher phosphorus, and there are streams and rivers that have lower phosphorus. It's very site-specific. It depends on where you look.
Q. Could you provide the court with sort of an overview of how you went about your comparative analysis of phosphorus levels in the watershed to other available data.
A. In the watershed, my major comparison for that would be the comparison to Oklahoma statewide. I did some comparisons with the IRW to national datasets as well, but the Oklahoma one, what I did was to pull together the data from three data sources.

These were the sources that had large volumes of data on total phosphorus from different streams throughout Oklahoma. It was EPA STORET, Oklahoma Water Resources Board, and the U.S. Geological Survey. So I pulled together data from those agencies for the state, including the Oklahoma portion of the IRW.

Q. Did you look at any regional or national data on phosphorus concentrations?

A. Yes.

Q. And could you identify generally what information and data was available to you for that analysis?

A. There was data from EPA. There was data from USGS. There was a study done primarily in Oklahoma, there were over 500 samples. There were a few in Arkansas, but the vast majority in Oklahoma.

Q. Doctor, based upon the data that you have reviewed, have you formed an opinion as to whether or not phosphorus levels in the Illinois River Watershed streams and rivers are generally higher than phosphorus levels regionally or across the country?

A. Based on the analysis I did, there's no reason to think that those samples are different than what

we see other places. They're in the same range of what we find many places.

Q. Doctor, could you turn -- do you have a binder in front of you with some exhibits in it?

A. Yes.

Q. Okay.

MR. GEORGE: Your Honor, hopefully one has been provided to you and counsel has one.

Q. (By Mr. George) Could you turn to tab 1 in that notebook, please, and find Tyson Defendant Demonstrative 355.

A. Yes.

Q. Doctor, did you prepare this demonstrative exhibit?

A. Yes, it was prepared under my direction.

Q. And what data is set forth in this exhibit?

A. This would be the median total phosphorus concentration in streams at different locations and from different studies.

THE COURT: Before we go any further, Mr. George's question asked you whether or not you had an opinion regarding phosphorus levels being generally higher than phosphorus levels regionally or across the country. Just so I have an overview before we get into this, let's focus on this

particular ecoregion.

Are, in your opinion, phosphorus levels in the IRW generally higher than phosphorus levels within the ecoregion?

THE WITNESS: For the most part, I would say that that's true.

THE COURT: They're higher --

THE WITNESS: They are higher than the ecoregion --

THE COURT: That was a compound question. I wanted it to be a little clarified. Go ahead.

MR. GEORGE: Thank you, Your Honor.

THE COURT: Go ahead.

Q. (By Mr. George) Dr. Sullivan -- and I'm glad His Honor asked that question, because we were going to walk through this exhibit which I think will illustrate exactly that point.

Dr. Sullivan, can you walk us through Tyson Defendant Demonstrative 355 and explain what it shows in terms of the comparison between phosphorus levels and streams and rivers in this watershed to the other data that was available.

A. Okay, I'll do my best. It's a little bit of a complicated plot. In the middle, we have the two brown bars that are the median from Dr. Olsen's

master database. We've got a base flow bar, and we've got a bar to represent all flow. So that gives an idea from the thousands of samples that Dr. Olsen collected in the IRW what the levels were. Then the two to the right of that were from streams that were analyzed by Dr. Stevenson in his biological studies.

And he sampled, I think it was four or five -- I think it was four points in time. And the point in time would have been, say, the spring, for example, in a year like 2006. So he had about four points in time. And I reported his upper and his lower so we'd see what kind of range he picked up in terms of median phosphorus.

Q. What were his ranges?

A. From essentially 0.6 to 0.8.

Q. Doctor, with respect to Dr. Olsen's water quality data, what were the ranges of medians in terms of phosphorus concentration within that dataset for the Illinois River Watershed?

A. They were both about 0.6.

Q. And if you could continue explaining how those values relate to the other available data.

A. Okay. So those values compare to a nationwide survey. We can look at two nationwide surveys.

We've got the one on the far left, that's the USGS survey. And the median concentration there would be about double what we have in the IRW. Then we could go to -- so that would be the one for the U.S. Then we would go --

Q. Let me stop you there, Doctor. The value for the United States of .12 milligrams of liter for total phosphorus, is that what it sounds like, a nationwide survey of streams?

A. It's a nationwide survey of rivers, 250 rivers.

Q. Thank you.

A. So the minimum size was -- I believe it was a thousand square kilometers. That's quite a bit smaller than the IRW, but it's still a good-size system. So those are rivers.

Q. Just so we're clear, Doctor, how do the phosphorus levels reported by the State's experts for the Illinois River Watershed streams and rivers compare to the median value nationally for rivers?

A. The IRW is about half of the national level.

Q. Thank you. If you could continue with the discussion of the USGS and OWRB dataset.

A. Those data were 563 sites in Oklahoma. There were just four Arkansas sites. So it's principally an Oklahoma database. I think this points out an

important issue, is that the result that you get depends partially on what size stream you're looking at in many cases. That's not always the case, but oftentimes that's the case.

And so on the larger streams, fourth order and larger, it was actually fairly close to the USGS number. But then on the smaller streams, it was lower, and it would depend on how steep those streams were.

For perspective, the IRW where it flows into Lake Tenkiller is a seventh-order stream. So that's a bit bigger than the fourth and higher here.

Q. Doctor, if we could turn now to the Wadeable Streams Assessment information that's shown here. Did you have available a database from EPA in connection with this Wadeable Streams Assessment?

A. Yes.

Q. Is that, again, a national database?

A. Yes. It's another database that was selected with a statistical basis.

Q. I notice you have two different median values reported from that dataset for your comparisons here. Could you explain that?

A. Yes. I picked out the sites in Oklahoma and Arkansas. There were 57 of those, so it's quite a

few. But I do need to provide the caveat that the study was not designed such that the data from any one state would be statistically representative of that state. But, nevertheless, we have quite a few sites, so I think it's very illustrative.

Q. What were the median phosphorus concentrations in the 57 sites in this survey in Oklahoma and Arkansas?

A. They were about .05.

Q. How does that compare generally to the phosphorus concentrations reported by Dr. Olsen and Dr. Stevenson for the Illinois River Watershed?

A. Very similar.

Q. Now, I notice -- and I think this gets to His Honor's question. That the last bar on this exhibit is described as Ozark and Ouachita segment of the SA ecoregion. Do you see that?

A. Yes.

Q. What is the SA ecoregion?

A. That's the Southern Appalachian ecoregion. The thing we have to be careful of with ecoregions is that there are multiple schemes that are used. So the ecoregion scheme that was used for EPA's Wadeable Stream Assessment that was published in 2006 was what's called an Omernik Level 1 ecoregion.

So they're fairly large.

The ecoregion scheme that was used in the Wadeable Stream Assessment that was published by EPA in 2006 was what's called an Omernik, a person's name, Omernik, O-M-E-R-N-I-C-K, Jim Omernik. Omernik Level 1. So those are large.

The southern Appalachian ecoregion that they used includes the IRW, the Ozarks, and Ouachita, but it extends all the way up to Pennsylvania. So it's quite a large ecoregion.

Then there are level 2 and level 3 ecoregions as well. The level 3 ecoregion is a much finer scale. That would be -- the Ozark area would be a level 3.

Q. Is that the ecoregion in which the Illinois River Watershed is situated?

A. It's situated in both. It depends on what scale you're looking at. Then there are other regions, too, that are maintained by the Forest Service that are different from Omernik. But depending on which level you're looking at, the answer is yes.

Q. Doctor, with respect to the Ozark and the Ouachita segments of that ecoregion, what was the reported phosphorus concentration median value

within that dataset?
A. That was about .01.
Q. And do you agree that's lower than the phosphorus concentrations that are reported in the data by Dr. Olsen and Dr. Stevenson for the Illinois River Watershed?
A. Yes, I do.
Q. Okay. Doctor, did you evaluate the land uses within the watersheds that comprise the value of .011 phosphorus in the Ouachita and Ozark segments of the ecoregion?
A. Yes, I did.
Q. How did those land uses, in terms of development and pasture versus forest, compare to the Illinois River Watershed?
A. Well, the big difference is the amount of forest. The amount of forest is a really important variable in looking at phosphorus in streams, is how much forest is in your watershed. If the watershed is forested, you typically -- not always, but typically -- will have much lower levels of phosphorus in the water than if your watershed has other land uses that are more impacted by people and their animals: Urban areas, rural residential areas, agricultural areas of all types. So that's

not a surprise.

The level of forest in the watersheds that were sampled by EPA in this study, I think that the average was about 72 percent of the watersheds that were included in that Ozark/Ouachita were forested.

Q. How does that compare to the percentage of forestland in the Illinois River Watershed?

A. Illinois River Watershed forest is much lower, it's in the 40s; maybe 43, 45 percent, something like that.

Q. Does that difference in percent forest have any impact on your comparative analysis and the conclusions you draw from this reported value for the ecoregion of .011?

A. Well, it does. It's partially a function of how much forest you have, and it's also partially a function of the watershed area. The watersheds that were included in the EPA study tended to be very small. They were all quite a bit smaller than the IRW, but they tended to be a very small fraction of the size of the IRW.

Q. How does the watershed size impact the relationship one would expect to see with phosphorus concentrations?

A. Well, in larger watersheds, you're far more

likely to be picking up agricultural and urban lands as you move downslope. The typical situation in the United States is that if you're looking at your watersheds, the top sections -- if you're in a forested region or generally forested region, the top sections of your watershed are most likely to be forested and on steeper slopes. Then as you move downhill to lower elevations, you tend to get more flat terrain that's more suitable for agriculture.

So in the larger watersheds that pick up that additional real estate downslope, you're more likely to get more urban and agriculture development.

I want to point out something that's really important in this evaluation is that the IRW is in a lot of ways upside down in the sense --

MR. BULLOCK: I'm going to ask that the witness restrain himself to only ask questions -- answer the question asked rather than giving long soliloquies.

THE COURT: Sustained. Mr. George, go ahead.

Q. (By Mr. George) Dr. Sullivan, is there another aspect of difference between this watershed and the watersheds included in the ecoregion data that you

looked at that you believe is important and may explain some of the differences?

A. Yes. I think this business of the IRW being, to some extent, upside down and that the more typical pattern -- it's not universal, by any means, but the more typical pattern is in the watershed, you have your forested land at the top and steeper slopes, and as you move downhill, if you're going to have ag lands, you'll pick it up generally at the lower elevations that tend to be flatter. Same thing for the urban areas. That's the typical pattern that I'm used to seeing in lots of places around the country and lots of studies.

In the IRW, in contrast, most of the urban development is concentrated at the very top of the watershed. And so you have urban impacts influencing the headwaters of the system. And then as you start to move downstream, you're picking up more and more of the agricultural influences.

Actually, most of the forests are the furthest downstream. So you have -- whatever pollutants might be associated with human activity, you're seeing them at the top, in the beginning, which is the opposite of what we normally find.

Q. Doctor, when I look at Demonstrative 355, I

notice on the vertical axis that your analysis is based upon total phosphorus; is that right?
A. That's correct.
Q. Why did you use total phosphorus in your analysis?
A. For multiple reasons. I think the most important one is because the water quality standard that's scheduled to take effect in a couple of years in the IRW is based on total phosphorus, and that's what this lawsuit is about. So I mean, that was good justification.

But in addition to that, when I'm looking for data, there typically are more data available for total phosphorus because it's more commonly measured than other forms, like soluble reactive phosphorus or other forms of phosphorus.

Then the final issue is that, to some degree, the forms are interconvertible. I didn't do calculations to evaluate how long that would take or the way that might occur, but there are interconversions that can take place, so if you do total phosphorus, then you're capturing all of the phosphorus that's there.
Q. Doctor, did you also undertake any comparison of phosphorus concentrations in streams and rivers

in the Illinois River Watershed to phosphorus concentrations reported for streams and rivers throughout the state of Oklahoma?
A. Yes, I did.
Q. And what sources of data did you use in that analysis?
A. I used EPA STORET, Oklahoma Water Resources Board and U.S. Geological Survey.
Q. Doctor, in that analysis, that comparative analysis, did you compare individual samples or did you aggregate the data?
A. I aggregated the data.
Q. Why did you do that?
A. So that we could see the spatial patterns. I'm interested in what the phosphorus concentrations are like at different locations. And it's a much more robust analysis if you include a number of data points for each location.

There are many reasons why you might see a particularly high or particularly low value for any parameter, including phosphorus. So to best capture of what's going on at a particular location, you'd like to have multiple samples. And so that's why I aggregated them.
Q. That comparative analysis for the statewide

work in Oklahoma, did you compute something that's referred to as geomeans?
A. Yes, I did.
Q. What is a geomean?
A. It's also called a geometric mean. It's a measure of central tendency for the data. There are basically three measures of central tendency that are commonly used in environmental data. There's a fourth, but it's very seldom used. One is the mean or the average. There's the median, and the third is the geomean.
Q. Doctor, are you aware that the .037 criterion that you mentioned earlier is expressed as a geometric mean, or geomean?
A. Yes.
Q. Do you have an understanding as to whether, for that purposes of that standard, there is some time frames around the number of samples over a period of time to compute the geomean?
A. That's correct.
Q. What are those time constraints and requirements?
A. Five or more samples over a 30-day period.
Q. Doctor, did you limit your geometric mean analysis of the statewide phosphorus concentration

data to samples collected at a site within 30 days?
A. No, I did not.
Q. Why not?
A. Well, the main reason I didn't was because I wouldn't have had enough data points to do the spatial analysis that I was trying to do. And if I had had enough data points, I would be restricting them further by eliminating a lot of my data by that restriction. Again, when you have more data, it's a much more robust analysis of spatial patterns.
But the final reason was that it's really not necessary or useful for me to do that. Environmental studies are typically not conducted that way for looking at spatial patterns. I was not trying to evaluate regulatory compliance of any sort. I was trying to evaluate the spatial patterns and available data.
Q. You used a phrase that I'm not sure has been used in this case yet, but "spatial patterns." Could you, for the benefit of the record, describe what that is.
A. Spatial pattern analysis is something that I do quite a lot of in my field. And it's a way of looking at the data that we have, either we collect it ourselves or we obtain it from government

agencies or other groups, and trying to see how the concentrations -- typically what we look at, how those concentrations change across space. Are they going up as you move downhill? Are they going down? Are they high in one region? Low in another region? What are the patterns in the concentrations expressed as a measure of central tendency across space? And how are those patterns related to the things that we believe might influence those patterns, different kinds of land uses, different activities, different pollution sources or whatever?

Q. Doctor, did you include in your report maps plotting the geometric means for total phosphorus levels in streams and rivers across the state?

A. Yes.

Q. Could you turn in your notebook or binder to tab No. 2.

A. Yes.

Q. And could you identify for the record what's been marked as Defendants' Joint Exhibit 2221.

A. Yes. That's a map from my report.

Q. And was this figure prepared under your direction?

A. Yes, it was.

Q. Doctor, could you identify the source of the data that's represented on this figure?
A. Oklahoma Water Resources Board.
MR. GEORGE: Your Honor, I move for the admission of Joint Exhibit 2221.
MR. BULLOCK: No objection.
THE COURT: Defendants' 2221 is admitted.
Q. (By Mr. George) Doctor, could you explain how this figure was prepared and explain what it shows in connection with your spatial analysis.
A. Yes. The -- on the map of Oklahoma, there are small black dots at the base of each of these bars. And those dots represent the locations where samples were collected. And we plotted all the locations where there were five or more samples available to evaluate that were collected during the time period between 2000 and 2007, and then the data for each location would be represented as a geomean of those available data.
So each location has a bar. The location of the site is identified by the black dot. The height of the bar is proportional to the concentration. And the scale bar is down at the bottom middle. It shows you the height of a bar that would be 0.5 milligrams per liter of total

phosphorus. Then there's an inset map that blows up the IRW so you can see it a little bit better.
Q. Doctor, the Illinois River Watershed and the data from OWRB related to that watershed is shown on this map; is that right?
A. That's correct.
Q. Doctor, what does this analysis show about the levels of total phosphorus in streams and rivers in the Illinois River Watershed compared to levels of total phosphorus in other streams and rivers throughout the state of Oklahoma?
A. Well, it shows a number of things. One is, I neglected to point out in your earlier question, that the color of the bars has some meaning. If the bar is colored green, that means that the geomean concentration was below the .037 value. If the bar was orange, that was above the .037 value.
Q. Let me stop you there, Doctor. You're not suggesting, are you, that the .037 standard applies throughout the state of Oklahoma, are you?
A. No. The .037 is a scenic river standard. It's applicable in the IRW and some other places.
Q. Continue on with your answer, please.
A. So in terms of spatial patterns, we see several things. Most important to me in the context of this

case is that what we see for geomean concentrations in the IRW are not unusual compared to geomean concentrations elsewhere throughout the state. That would be the first thing.

The second thing is that where there is evidence that there are particularly high concentrations, they're not in the IRW but, rather, in the central part of the state. That would be the second conclusion. I can go into more detail if you'd like me to.

Q. Let me ask you to focus on the eastern third of the state of Oklahoma in this map, Dr. Sullivan. Based upon your review of the data, have you formed an opinion as to whether the waters in the eastern third of the state of Oklahoma demonstrate markedly higher phosphorus concentrations when compared to the rest of the state?

A. They do not.

Q. As part of your work in this case, did you evaluate levels of poultry production across Oklahoma?

A. Yes, I did.

Q. What did you learn as a result of that evaluation?

A. That the poultry densities are highest by a lot

in the eastern part of the state.
Q. Did you include a figure in your report that shows a representation of that data?
A. Yes, I did.
Q. Let me ask you to turn to tab 6, please.
A. Yes.
Q. And let me ask you to identify for the record what's been marked as Defendants' Joint Exhibit 2225.
A. That's a figure from my report.
Q. Okay. Was this report prepared under your direction?
A. Yes, it was.
Q. And what data is shown on this report?
A. Total poultry numbers by county throughout Oklahoma for the year 2002.
Q. What's the source of that data?
A. The Oklahoma 2002 Census of Agriculture.
MR. GEORGE: Your Honor, I move for admission of Defendants' Joint Exhibit 2225.
MR. BULLOCK: No objection.
THE COURT: Defendants' 2225 is admitted.
Q. (By Mr. George) Dr. Sullivan, does this map illustrate what you were just saying regarding poultry production being largely confined to the

eastern third of the state?
A. Yes, sir.
Q. Now, let's go back, if we can. And could you turn to tab 3. Find what's been marked as Defendants' Joint Exhibit 2222.
A. Yes.
Q. And could you identify that document for the record, please.
A. That's a figure from my report.
Q. Was this figure prepared under your direction?
A. Yes.
Q. And does it show some data represented on the figure?
A. Yes, it does.
Q. What's the source of that data?
A. EPA STORET.
Q. Doctor, does this figure follow the same format as Defendants' Exhibit 2221, just uses a different dataset?
A. That's correct.
MR. GEORGE: I move for the admission of Defendants' Joint Exhibit 2222.
MR. BULLOCK: No objection.
THE COURT: 2222 is admitted.
Q. (By Mr. George) Doctor, why do we have two maps

of the state of Oklahoma with these bars of phosphorus concentrations?
A. There are two different data sources.
Q. And the data source with respect to Defendants' Joint Exhibit 2222 is EPA STORET; is that right?
A. That's right.
Q. Doctor, what conclusions do you draw from your review of this data?
A. The same conclusions that I drew from the Oklahoma Water Resources Board data, that the concentrations of total phosphorus expressed as a geomean are not unusual in the IRW compared to the rest of the state. In fact, where we do see a pattern -- a spatial pattern of somewhat higher values, it's in the central part of the state.
Q. If you could turn back to tab 2, which is Defendants' Joint Exhibit 2221, and look at the inset of the Illinois River Watershed. Can you find that, please.
A. Yes, sir.
Q. I notice that there is one bar in this dataset that appears to be higher than the rest. Do you see that?
A. Yes.
Q. What's the location of the water quality

sampling site that is reflected by those higher concentrations of phosphorus?
A. It's on Sager Creek about three miles below the Siloam Springs wastewater treatment plant.
Q. Now if we could turn to tab 4, please. If you could find Defendants' Joint Exhibit 2223.
A. Yes.
Q. Could you identify that document for the record, please.
A. It's a figure from my report.
Q. And was this figure prepared under your direction?
A. Yes, it was.
Q. Does this figure involve the same formatting of data statewide that we've seen in the prior two exhibits?
A. Yes.
Q. Doctor, what's the source of the data shown on this figure?
A. U.S. Geological Survey.
MR. GEORGE: I'd move for the introduction of Defendants' Joint Exhibit 2223.
MR. BULLOCK: No objection.
THE COURT: 2223 is admitted.
Q. (By Mr. George) I note on this map we have

fewer bars than some of the ones we've seen previously. Do you have an explanation for that?
A. There's just fewer data available in terms of number of locations with the USGS data than the other two data sources.
Q. Doctor, do you draw any conclusions from this dataset regarding how phosphorus levels in the watershed compare to phosphorus concentrations statewide?
A. I wouldn't draw conclusions in a spatial analysis from this dataset. There simply are not enough data points represented to do that. But I would say that they're not inconsistent with what we've seen elsewhere.
Q. Last map, Doctor. If you could turn to tab 5 in your binder and find Defendants' Joint Exhibit 2234.
A. Yes.
Q. Can you identify for the record this exhibit.
A. It's a figure from my report.
Q. Was it prepared under your direction?
A. Yes.
Q. And, Doctor, can you identify the source of the data that is shown in Defendants' Joint Exhibit 2234.

A. This is a combination of all the data shown on the three previous figures with data from EPA STORET, Oklahoma Water Resources Board and USGS.
Q. Why, Doctor, did you combine all of that data into one map?
A. I think it's, again, the more data you have, the better you can resolve your spatial patterns and see what's going on spatially across the area of interest. There's no reason why they have to be separated simply because they're different datasets. I thought it was useful to look at them separately, but then a combined map is -- I think is even more illustrative simply because you've got more data.
MR. GEORGE: I move for the introduction of Defendants' Joint Exhibit 2234.
THE COURT: Any objection?
MR. BULLOCK: No objection.
THE COURT: 2234 is admitted.
Doctor, in terms of comparison and -- wouldn't a more helpful comparison have been those waterbodies within this Ozark subecoregion? Oklahoma has quite a variety of different hydrological systems.
THE WITNESS: Yes.

THE COURT: Now Oklahoma River, formerly the Canadian, that goes through Oklahoma City is quite different. The Arkansas comes across the Great Salt Plains and Kansas. This is quite a different type of waterbody than those out in western and central Oklahoma, aren't they?

THE WITNESS: Yes, they are.

THE COURT: In terms of phosphorus. Now, your focus on the west coast, the Tillamook, T-I-L-L-A-M-O-O-K; is that right?

THE WITNESS: Yes, sir.

THE COURT: That focus was basically on bacterium because of oyster production, or what was it?

THE WITNESS: Different studies focused on multiple things. We focused on total suspended solids, nutrients, temperature in some of the studies. But the fecal indicator bacteria, fecal chloroforms was a major part of what we did.

THE COURT: What was the instigator of that? Was that oyster beds?

THE WITNESS: Oysters.

THE COURT: I remember sometime in the past, they were suggesting that one not eat oysters from certain areas.

THE WITNESS: Correct.

THE COURT: Was this one of those areas?

THE WITNESS: Yes.

THE COURT: All right.

THE WITNESS: But I would say, Your Honor, if I may, is that the question of the ecoregion comparison, it really depends on what the question is that you're asking. And the reason is because people and their animals can put phosphorus into any stream. It doesn't matter what ecoregion you're in.

In terms of evaluating the phosphorus in the IRW compared to other watersheds, the best comparison would be to look at watersheds that had similar land use and similar populations of cattle and people and whatnot, and different levels of poultry. That would really be a way to get at the questions that the court is most concerned with.

THE COURT: Hopefully with a similar geology, right?

THE WITNESS: Well, the similar geology is important mainly with respect to what the background or pristine level would be.

THE COURT: Of course, that's what generates a lot of the concern here, because

everybody remembers how pristine this area was. It was crystal clear.

THE WITNESS: Uh-huh. But to me, the issue there is that what's assumed -- we don't know what the background level is, but what's assumed to be the background level throughout most of the U.S., really not a large variation there.

THE COURT: This is -- with all due respect, this isn't most of the U.S. It's really not.

THE WITNESS: Right.

THE COURT: This was a -- there's testimony on this record that this was pristine water, all right?

THE WITNESS: Correct.

THE COURT: It's not the rest of the United States. And so you really have to look at the background at what the reference was, right?

THE WITNESS: Exactly, Your Honor. That was the point I was trying to make, but not very well, I think. The point is that the background, even though there are various geologies, probably didn't differ all that much.

People have been throwing out background levels in this case for the IRW. Nobody knows what

it was, but you're looking at .01 to .02 milligrams per liter, something like that for phosphorus. So we're looking at values that are higher than that.

THE COURT: As part of your analysis here, did you look at those argued reference points, Nickel's Preserve, etcetera?

THE WITNESS: I certainly looked at the Nickel Preserve, but I was thinking in terms of the background levels for the stream themselves and for the lakes. There have been numbers bantered about. And in terms of the ecoregional specificity, that's really, to me, what would be most important is that would have an influence on what the background level is. But when you rise above that background anthropogenic influence, then the ecoregional foundation becomes less important and less useful.

THE COURT: Go ahead.

MR. GEORGE: Thank you, Your Honor.

Q. (By Mr. George) Dr. Sullivan, are you aware of another watershed in this particular ecoregion that has the same percent forest, for example, that you believe would be a classically appropriate reference watershed?

MR. BULLOCK: I don't recall this opinion in his expert report. If counsel could --

MR. GEORGE: I actually was trying to follow up on the questions the court asked, because I think they are important. And that was the purpose of the question, Your Honor.

THE COURT: I'm going to sustain. I probably went farther than I ought to have.

MR. GEORGE: No, I wanted to address Your Honor's questions, if I could, but I appreciate the court's ruling.

THE COURT: No, I appreciate it.

Q. (By Mr. George) Doctor, let's turn to another comparative analysis that you did in your work in this case. Did you conduct an evaluation of phosphorus levels in Lake Tenkiller as opposed to phosphorus levels in the streams and rivers?

A. I compared -- not quite -- a comparison with the lakes rather than streams and rivers.

Q. I'm sorry. Let me clean up my question. Doctor, did you conduct an evaluation of the phosphorus levels in Lake Tenkiller as opposed to the phosphorus levels in the rivers and streams? Did I ask the same question?

A. Yes.

Q. Let me try it again. Doctor, did you compare water quality data for Lake Tenkiller to water

quality data for any other lakes or reservoirs?
A. Yes, I did.
Q. Did you focus on other lakes in the state of Oklahoma?
A. No.
Q. Okay. Why not?
A. I wanted to follow up on some of the comparisons that I had done in those larger regional comparisons. And Dr. Connolly was focused on a comparison with the rest of Oklahoma, and I didn't want to duplicate the work he was doing.
Q. Did you have available some data on other reservoirs in what's referred to as the central states region?
A. Yes.
Q. And for the benefit of the record, what geographic area is comprised in the central states region, just generally?
A. Well, for the reservoirs, those actually were not focused on the central states together. They were focused on the state of Missouri.
Q. Okay. What data did you have available on reservoirs from the state of Missouri?
A. Data in a publication by Jones, et al. in 2004.
Q. Doctor, is this the same Jack Jones who there's

been some testimony about being a consultant for the State of Oklahoma in this case?

A. I've heard that, but I don't know that for a fact.

Q. Okay. You had this dataset on reservoirs from Missouri. Did you compare that to any water quality data for Lake Tenkiller?

A. Yes, I did.

Q. And, Doctor, did you compare it to water quality data from all of the sampling stations in Lake Tenkiller?

A. No.

Q. Why not?

A. Well, the data represented in the Jones, et al. publication was for 135 reservoirs in Missouri, and they were each sampled at a location near the dam. And that's important when you're comparing information among lakes,

If you're going to collect a sample to characterize a lake, not to do an in-depth study across the lake.

But to characterize a lake for a regional study, you typically sample at one location, that's the deepest part of the lake. It's called the index sample by EPA. That's how they do all their broad

surveys. In a reservoir, the deepest part of the lake is generally quite close to the dam.

And this particular study I was comparing to -- had data that were collected close to the dam. So that would be analogous to the index sample of EPA and analogous to the LK-01 site in the Tenkiller database.

Q. Doctor, based upon the analysis you've just described, how do the phosphorus levels at this location in Lake Tenkiller compare to the phosphorus levels in this report on Missouri reservoirs at similar locations?

A. Well, the median concentration in the Missouri reservoirs was quite a bit higher than the data that were presented by the plaintiff's Drs. Cooke and Welch in their report for the years 1974, '92, '93, 2005, 2006 and 2007.

Q. Doctor, did you include in your report a figure that displayed the data that we've been discussing?

A. Yes.

Q. Could you turn in your notebook to tab 7.

A. Yes.

Q. Could you find Defendants' Joint Exhibit 2275.

A. Yes.

Q. Could you identify this figure for the record.

A. It's a figure from my report.
Q. Was this figure prepared under your direction?
A. Yes, it was.
Q. Does it contain the water quality data from lake station 1 in Tenkiller and the 135 Missouri reservoirs that we've just been discussing?
A. Yes. The point of that was to compare apples with apples on the plot.

MR. GEORGE: Your Honor, I'd move for the introduction of Defendants' Joint Exhibit 2275.

THE COURT: Any objection?

MR. BULLOCK: I'm going to object to this in terms of hearsay as to representing what this other study says about 135 Missouri reservoirs.

MR. GEORGE: May I respond?

THE COURT: Yes.

MR. GEORGE: Neither Dr. Sullivan nor this exhibit is offering hearsay testimony about any conclusions or statements made in this study. He is simply using the data that is available, which is common practice for scientists, and I believe, therefore, qualifies under Rule 703.

MR. BULLOCK: It's not his data and he has not done the analysis, and so to arrive at what he claims to be the median value clearly is hearsay

from somebody else's work and calculations.

THE COURT: All right. Is it clear -- did the witness on the stand come to the conclusion regarding the median or was that reported?

MR. GEORGE: Let me lay the foundation, Your Honor.

Q. (By Mr. George) Dr. Sullivan, is the median value that is shown on Defendants' Joint Exhibit 2275 the product of a computation that you performed?

A. No.

Q. Okay. Is it the value that is reported with the sampling data in this study?

A. Yes.

Q. Okay.

MR. GEORGE: There you go, Your Honor.

THE COURT: I believe it's permissible under 703 for an expert -- Exhibit 2275 is admitted. What are we going to do since we're halfway between another witness? Is there some sort of agreement as to whether or not we're going to get the previous witness or attempt to get through with the previous witness today?

MR. GEORGE: Mr. Elrod and I were going to fight it out. No, actually, Your Honor, I'm about

five minutes away from a natural breaking point in the direct. If it's appropriate and the court is agreeable --

THE COURT: That would be fine. We're going to go back, correct?

MR. ELROD: Correct.

THE COURT: Mr. George.

MR. GEORGE: Thank you, Your Honor.

Q. (By Mr. George) Doctor, can you, using Defendants' Joint Exhibit 2275, explain how the phosphorus concentrations that you had available for lake station 01 and Lake Tenkiller compare over time to the reported values from the 135 Missouri reservoirs?

A. Yes, sir. During the period -- well, the three data points for 1974 through 1993 were all relatively comparable, and they were about .025 milligrams per liter of TP.

The most recent three years that were sampled by the plaintiffs and included by Drs. Cooke and Welch in their report for 2005, 2006 and 2007, they were all right around or right above .01. Both the values from the 1970 and through 1990 periods of time and the more recent values, they're both substantially less than the median.

In fact, the most recent values are substantially less than the 25th percentile of the Missouri data which is represented by that bar that extends above and below the median point.

Q. Doctor, did you limit your comparison of phosphorus levels in Tenkiller with other reservoirs to the 135 Missouri reservoirs, or did you look elsewhere?

A. I'm sorry, can you repeat that?

Q. I'm sorry. Did you, as part of your work in this case, provide a comparison of water quality at lake station 01 with any other data on reservoirs?

A. Yes, I'm sorry. Yes, I did that.

Q. And, Doctor, could you identify the other data that you had available to you to provide further insight into this comparative analysis?

A. Yes. It was the dataset from the central states. They were -- the samples were collected in Missouri, Iowa, Nebraska, Kansas and the southern part of Minnesota. It was in the study published by Graham, et al. in 2004.

In this case, these were not restricted to reservoirs. A reservoir is a type of lake. These are lakes.

Q. Doctor, within that other dataset that you

reviewed, did you have available any data on lakes in the Ozark Highlands?

A. I -- I'm not sure, to tell you the truth, if any of the Missouri data were in the Ozarks.

Q. I'm referring now to the central states study, Doctor. And perhaps if you could look at tab 8 in your binder and find Tyson Defendant Demonstrative 35 -- I'm sorry, 354.

A. Yes, I have it.

Q. And, Doctor, does this demonstrative -- first of all, was it prepared by you?

A. Under my direction, that's correct.

Q. And, Doctor, does it report the data that you had available from this other source on lakes and reservoirs outside of Missouri?

A. Yes.

Q. And does it include data on a region --

MR. BULLOCK: Judge, before we get any further into this, the same objection as previous. This clearly is hearsay being represented for the truth of the matter asserted.

MR. GEORGE: Your Honor, it would be the same response. The witness has simply taken data that's publicly available and has analyzed that, as experts are permitted to do. He's not going to

testify as to any conclusions or statements drawn by the authors in any study or report.

THE COURT: Overruled. Go ahead.

Q. (By Mr. George) Doctor, could you walk us through Tyson Demonstrative 354.

A. Yes. If we go to the green bar in the middle of the figure, those would be the same data from the Jones, et al. study we just talked about. That's placed there for context, as are the three blue bars on the right side, which would be the Lake Tenkiller data from lake site 01 from Cooke and Welch from their expert report.

The orange bars on the left side of the figure are different subsections of that study within the central states, so we have median total phosphorus concentrations reported for four different regions including the Ozark Highlands at the lower end on the left all the way up to what they call the Western Lake section on the right.

Q. Since we're creating a written record here, could you identify some of the numeric values on the median phosphorus concentrations, beginning in the data that you had available for lake station 1 in Tenkiller and then continuing on through the other available data.

A. Yes. The Tenkiller data for lake station 1, they were all around or a little bit above .01 milligrams per liter of total P. .01, .011 and .012, so very similar.

The Missouri values, again, were close to .04 for median. Then for the Graham, et al. study, the values ranged from Ozarks Highlands, which was about .012; Osage Plains, which was .045; dissected Till Plains, which is .079; and Western Lake section, which is .141.

Q. Doctor, the lowest value I see on there outside of the data reported for Lake Tenkiller is the .012 for Ozark Highlands; is that correct?

A. That's correct.

Q. How do the Lake Tenkiller data that's shown on this demonstrative compare to that value?

A. The recent values for Lake Tenkiller are very, very similar to that value.

Q. Doctor, what conclusions, if any, do you draw from the data that you have reviewed regarding lake phosphorus concentrations as compared to the Lake Tenkiller data?

A. I see no evidence that Lake Tenkiller is particularly unusual in terms of having high phosphorus; and, if anything, is actually low

compared to other lakes and reservoirs with the exception of Ozark Highlands, where it's comparable.

Q. Once again, Doctor, you applied your analysis in this demonstrative to the data that's available at the deepest part of the lake, correct?

A. In this study, they didn't specify that it was collected from the deepest part of the lake. They specified they were mostly pelagic samples, which is open-water samples. So we don't know to what extent is exactly analogous, you know, a la all EPA style of the index site. But clearly it's skewed in that direction based on how it was described.

Q. Doctor, I believe you have reviewed the testimony of Dr. John Connolly regarding the riverine portion of Lake Tenkiller. Did you see that testimony?

A. Yes, I have.

Q. Have you conducted any particular comparative analysis on the riverine section of the lake?

A. No, I have not.

MR. GEORGE: Your Honor, this is a good place to perhaps reinterject the witness that we were examining before lunch.

THE COURT: Very well. Let's do so.

Mr. Garren, you may resume your

cross-examination of Dr. Dicks.

DR. MICHAEL DICKS,

having been previously duly sworn, was called as a witness and testified as follows:

CONTINUED CROSS-EXAMINATION

BY MR. GARREN:

Q. Dr. Dicks, you'll be glad to hear that I've made judicious use of my time while we've been waiting here, and have cut a lot of questions out of my questions this afternoon, so we should move through this fairly quickly.

In following up about some more IMPLAN model questions, Dr. Rausser discussed in his testimony the term "externalities," and I want to ask you a question about that.

You agree it's generally understood an externality would be where a company shifts some of its operating costs or byproducts or even negative effects to others in the market and that's generally what we would refer to as externality?

A. I believe an externality is a benefit or a cost that's not captured in the market.

Q. Okay. But it's one that one company may shift to another, correct?

A. No.

Q. You don't believe that?
A. I don't believe that.
Q. Okay. You agree that the IMPLAN model has been criticized for the fact that it assumes full employment?
A. It's been criticized for a lot of things. I'm not sure I'm aware of all of them.
Q. Would that be one of them?
A. I don't recall that, no.
Q. You don't agree that the assumption of full employment is one of the criticisms as to its base or at its base?
A. I think it depends on what you're using the model for, whether that's a criticism or not.
MR. GARREN: May I approach, Your Honor?
THE COURT: You may, sir.
Q. (By Mr. Garren) I've handed you State's Exhibit 3169, which I believe is in evidence in this case. And with regard to your calculation of a 45 STP average, in looking at Dr. Johnson's Exhibit 3169, would you agree with me that the average you've calculated would show that the percent sufficiency for both Fescue and cool-season grasses is in excess of 95 percent?
A. If -- again, I think we've been through this

before, but if you have a 65 STP at the time that you harvest a ton of forage, you're now below that. So if you start off with a 45 STP and you harvest a ton of forage, you're substantially below the sufficiency.

Q. Would you agree with me, sir, that if you are at a 45 STP, that based upon this exhibit, that would exceed 95 percent sufficiency?

A. Yes.

Q. All right. Now, are you aware of the rule of diminishing returns?

A. Yes.

Q. You agree that the cost to apply any fertilizer to raise STP from a 45 to 65 would be a good example of that rule or its application?

A. It could be.

Q. And you're bang for the buck is not -- it's clearly diminished if you're trying to just raise this STP level another five percent; would you agree?

A. At the moment you do it, but that doesn't take into consideration the time factor.

Q. You admit, don't you, Doctor, that your assumptions as to the land use, soil uniformity, livestock and agronomic practices are certainly

uncharacteristic for the IRW?
A. I'm sorry, can you repeat that.
Q. You admit that many of your assumptions as to the land use, soil uniformity, livestock and agronomic practices are uncharacteristic of the IRW?
A. I would say that the statistical approximations are certainly uncharacteristic, yes.
Q. You said that the nutrient czar -- and that was a term, I think, started by you and the judge in a set of questions -- was the Nutrient Management Plan, which determines spatial allocation of a litter; do you remember that testimony?
A. Yes.
Q. Would you agree that that spatial allocation is focused only on the field or fields within the plan?
A. Yes.
Q. And do you also agree it does not compare or analyze that field's condition and STP level to any adjoining field or fields?
A. Well, that depends.
Q. Have you seen a Nutrient Management Plan that compares it to a field or fields of another farmer?
A. No.
Q. All right. And the Nutrient Management Plan does not take into consideration the cumulative

effect of multiple fields; would you agree with that?

A. I have no way of commenting on that. It would depend on the person that's writing the plan.

MR. GARREN: I'll pass the witness.

THE COURT: Redirect.

MR. ELROD: Just a little bit, Your Honor. Appreciate your accommodation --

THE COURT: Certainly.

MR. ELROD: -- again.

April, would you put up Demo 352.

REDIRECT EXAMINATION

BY MR. ELROD:

Q. What is the header for this? Phosphorus levels for Adair, Cherokee, Delaware and Sequoyah Counties based on 2007 OSU soils data?

A. Correct.

Q. Correct?

A. Yes.

Q. Was this produced by -- information produced by Dr. Johnson, Gordon Johnson?

A. Yes, it was.

Q. For the counties of Adair, Cherokee, Delaware and Sequoyah, what was the median STP that Dr. Johnson opined existed?

MR. GARREN: Your Honor, this is outside the scope both of direct and cross-examination. We looked at a different one similar for the Benton and Washington, but this one is certainly new.

THE COURT: I don't recall Mr. Garren even getting into this on cross.

MR. ELROD: Yes, sir. This is an attempt to respond to Mr. Garren beating up the witness on his 45.5.

THE COURT: Mr. Garren, any response?

MR. GARREN: Well, understanding that the 45.5 is across the entire watershed, we're now focusing on half of it through this exhibit, and we've already talked about the other exhibit, so I still think it's outside any scope.

THE COURT: Overruled. Go ahead.

Q. (By Mr. Elrod) So in response to the proposition that there are very few fields under 45. I know we all know the answer to it this question, but the median means that the same number of samples on one side of the number as on the other side; is that correct?

A. That's correct.

Q. So when with a median of 55 in those four counties in Oklahoma from samples actually taken of

fields -- not nonsampled fields, not calculated, but actual samples -- half the fields would be under 55, and half of them would be over 55, according to Dr. Johnson?

A. That's correct.

Q. You testified about this ten-mile transportation area. And just to reemphasize --

A. Yes.

Q. -- was it your testimony, sir, that that assumed that the same farmer who produced the litter was going to put it on his own land?

A. Not necessarily, no.

Q. Why did you use the ten miles again?

A. Again, the farmer that owns that litter that sells it is going to sell it to a source that's closest to him, probably a neighbor. Based on what all the farmers have told me, it's going to someplace very close. So that we put a ten-mile limit on there as -- really as an exaggeration of the cost. It works against us to have that $1.78 in there, so I -- it's a conservative estimate.

Q. When you testified about biasing your -- being conservative in your numbers and biasing in favor of the State of Oklahoma, is it true, sir, that the effect of having calculated less litter would mean

less increase in STP, which would mean more available land to apply phosphorus and, therefore, the less litter that you calculated would be favorable to the State?

A. I guess what you're saying there, John -- let me try this. Certainly if we would have estimated less litter supplied, that would mean we would have a lower statistical approximation for the average STP, which would mean that the impacts would have been larger.

Q. Now, let's talk about this young lady named Lisa who actually punched the button on the computer; is that true?

A. That's correct.

Q. She works for Dr. Rausser?

A. Yes.

Q. And had for a long time?

A. Yes.

Q. Did you consult with her and him extensively throughout this process?

A. Yes.

Q. Are, generally speaking, cattle producers losing money right now at this point in history?

A. Yes.

Q. Are we at a down part of the cycle?

A. Yes. We're, unfortunately, at the down part of the cycle as well as a bad economy. Both things have worked against us -- against cattle producers.
Q. Have you yourself, as a cattle producer, reacted to the downturn in the economy?
A. Yes.
MR. GARREN: Objection. I'm too late. Relevance.
THE COURT: Little late. Go ahead. Overruled.
Q. (By Mr. Elrod) What did you do?
A. I reduced my cattle herd --
MR. GARREN: I am on time for that one. It's not relevant, Your Honor.
THE COURT: Sustained.
Q. (By Mr. Elrod) Has the -- have the states of Arkansas and Oklahoma reacted to a concern about phosphorus in these nutrient-rich watersheds?
MR. GARREN: Objection, outside the scope, Your Honor.
THE COURT: Sustained.
Q. (By Mr. Elrod) Are the IMPLAN results or the economic impacts that you testified to an annual impact?
A. They are an annual impact, yes.

MR. ELROD: Could you pull up Demo 371, please, April.

Q. (By Mr. Elrod) The $88 million negative impact on the bottom scenario --

A. Yes.

Q. -- to what extent, if any, will the $88 million economic impact be offset by economic activity outside the five counties?

A. Well, it wouldn't.

Q. Why is that?

A. This is the economic activity within the five-county area. Any economic activity outside of the area would not necessarily offset that.

Now, if you want to look at -- if you wanted me to do an IMPLAN run on the entire United States and say what would be the impact of this, well, you know, it's going to depend upon where all those activities fall out. There's definitely going to be a redistribution of those activities.

You'll find the same numbers for this location, for this five-county area, but you might find an increase in the trucking activity, you might find an increase in fuel expenses, you might find a lot of things. But you probably won't find a whole lot of increase in cattle output or cattle income.

Q. That's the impact on the cattle economy of northeast Oklahoma, northwest Arkansas that you are principally addressing in this exercise?
A. Yes.
Q. Doctor, can you explain to the court how a nutrient-surplus notion can co-exist with your opinion of 45.5?
A. Well, I mean, what I've studied is the farm fields within the IRW. And again, what we're talking about is what is the STP that's likely to exist, given the production practices that have been there.

I think -- I think I've demonstrated and shown quite handsomely with the results that are there from Johnson that there's a small number of fields that are biased and skewed to the right that represent those fields that have had lots of litter applied to them.

That means that because you have all those fields with lots of litter applied to them and you have a whole lot of fields must be, because if the average as we've computed is 45.5, if you have a large group that is -- have high numbers to the right of that mean, that means you have a whole lot of fields to the left side of that mean that have

very low STPs.

So my point is, is that there's a lot of fields in that IRW that still need to have phosphorus, whether you apply it as chemical or poultry litter, that's going to need that phosphorus in order to produce the forage they need to sustain the cattle in the watershed.

Q. You voiced -- what you said was that there was some criticism IMPLAN -- let me ask you this question. How widely used is IMPLAN?

A. IMPLAN --

MR. GARREN: Cumulative, Your Honor. He's already described its use.

THE COURT: Overruled. It was a matter on cross-examination.

THE WITNESS: IMPLAN is probably one of the most widely used models there is in the United States. It's used by businesses, it's used by county governments, it's used by state governments. Anytime there's an economic activity that somebody wants to consider, it's used to look at that impact.

Yes, there's lots of people that use the model that don't know what they're doing that produce results that may be a bit unscrupulous, but

I think that having been involved in design of the model and building the ag sector in that model, I think I have a pretty good enough understanding of how the model works and how it runs. And I think we've come up with results that are certainly reasonable.

Anytime you have a multiplier in the 1.7 to 2 range, I think you're on target.

Q. All right, sir. Thank you, sir.

MR. ELROD: I'll pass the witness to Mr. McDaniel.

THE COURT: Before you do, refresh my memory. You say whenever we have a multiplier of 1.7 to 2. What was your reference there?

THE WITNESS: The total impacts -- in other words, we've calculated here $88 million of total impacts and about a 45 -- $44 million direct impact. That ratio is two to one in this case, and that's a fairly common multiplier that you'll come up with.

Usually at the high end, when you have a lot of processing activities, you'll get a higher multiplier. It'll push 2.1, 2.2.

In Oklahoma, as a general rule, when you're talking about cattle, because most the cattle are

shipped outside of the watershed, you may have down to a 1.7 multiplier.

THE COURT: All right. Just to be clear here, because I thought you were also touching upon cattle production in Arkansas --

THE WITNESS: In Oklahoma, sorry.

THE COURT: Solely in Oklahoma?

THE WITNESS: In Oklahoma, when we looked at the Oklahoma industries, one of the problems we have in Oklahoma is that most of the products are not processed here in the state.

THE COURT: I understand that statement. But relative to your overall work here, you also took into consideration the cattle production on the Arkansas side, correct?

THE WITNESS: That's correct.

THE COURT: Okay. All right.

THE WITNESS: That's correct.

Q. (By Mr. Elrod) So when you see City boosters saying there's going to be a seven-time multiplier by building a stadium downtown, that's something you might be suspicious of?

A. I'd say that the builder probably produced that.

MR. ELROD: Thank you.

MR. GARREN: I object to any further examination by the defendants. It's a joint witness.

MR. MCDANIEL: Each of us -- just like we each had the right to cross-examine the plaintiff's witnesses.

MR. GARREN: This is a witness that they're presenting in their case as a joint witness on behalf of the joint defendants. We have had a direct. We've had a cross.

THE COURT: I think they've accommodated you in that sense. You sued a dozen poultry companies. I think they're entitled to, if they wish.

Mr. McDaniel, go ahead.

DIRECT EXAMINATION

BY MR. MCDANIEL:

Q. Dr. Dicks, good afternoon. I want to return very briefly to the notion of soil test phosphorus sufficiency for forage production.

Mr. Garren, in particular, asked you about Oklahoma Exhibit 3169. We've looked at that multiple times during the case, laying out different soil test phosphorus levels and levels of -- and how it meets agronomic need.

You mentioned earlier that there was a recommendation or another criteria that could be employed of 120 STP.

A. Correct.

Q. Can you explain what that is?

THE COURT: We don't -- that was Dr. Johnson's analysis. We don't need to go into that.

MR. MCDANIEL: He mentioned it here as a criteria, and it's a basis for my next question.

THE COURT: He talked about that, plus 300. He used the more conservative term, 65. Right, Doctor?

THE WITNESS: Yes.

THE COURT: Rather than using the alternate 120 of Dr. Johnson or 300 from the code.

MR. MCDANIEL: Right. That --

MR. GARREN: That's not in cross. I object, then. It's not part of cross.

THE COURT: Sustained.

MR. MCDANIEL: I haven't asked my question.

Q. (By Mr. McDaniel) The point is, had you, Dr. Dicks, employed the 120 recommendation for ensuring a hundred percent sufficiency fieldwide, would that have required more poultry litter to meet

that management scenario than the one you ran using 65?

MR. GARREN: Same objection. That was not inside the cross.

THE COURT: That's correct. It was brought up in direct. It wasn't touched upon in cross.

MR. MCDANIEL: Thank you.

CROSS-EXAMINATION

BY MR. GARREN:

Q. Dr. Dicks, with regard to the Demonstrative 352, that's only 1700 samples or observations in that particular dataset; do you agree?

A. That's a good point, yes. I agree.

Q. It's much lower than the one we looked at that you criticized for being small at 6500 observations; do you agree?

A. Absolutely.

Q. Now, if the herds are reduced, there would be less need for litter to grow more grass, wouldn't there?

A. There would be less need for nutrients, exactly. That's why the herds would be reduced.

MR. GARREN: No other questions.

FURTHER REDIRECT EXAMINATION

BY MR. ELROD:

Q. If the herds are reduced, Dr. Dicks --

THE COURT: I'm sorry, reredirect?

MR. GARREN: I don't know that we've done that.

THE COURT: We're not going to. We're not going to start it now.

MR. ELROD: You are telling me to sit down?

THE COURT: Yes, sir.

MR. ELROD: All right, thank you. That, I understand.

MR. GARREN: You should have seen our depositions, Judge.

THE COURT: I'm trying to digest here the recross here. 352 is what tab? Demonstrative 352?

MR. GARREN: Do you want me to show you?

THE WITNESS: The one-year soil samples for the four Oklahoma counties.

MR. GARREN: The blue bar chart with the Oklahoma counties at the top.

(Off-the-record discussion was had.)

THE COURT: All right. May this witness be excused?

MR. ELROD: Yes.

THE COURT: Now would be a good time to take a break. We're halfway through. Let's take our recess.

(Whereupon a recess was had.)

THE COURT: Mr. George, you may resume.

MR. GEORGE: Thank you, Your Honor.

DR. TIMOTHY SULLIVAN,

Called as a witness, being previously duly sworn, testified as follows:

CONTINUED DIRECT EXAMINATION

BY MR. GEORGE

Q. Dr. Sullivan, as part of your work in this case, did you review the sampling program and analysis performed by the State's various expert witnesses?

A. Yes.

Q. And in conducting that review, did you form any opinions as to the appropriateness of their sampling approach for purposes of evaluating potential sources of phosphorus that may impact water quality?

A. Yes, I did.

Q. And what was that opinion?

A. My opinion is that the sampling approach was very inadequate for doing that.

Q. How so?

A. Well, I think it's necessary to explain a little bit about how you might go about identifying sources.

Especially when we're talking about nonpoint sources, there are many different kinds, and they are located in many different places. That requires a very site-specific analysis. You need to bracket what you think might be sources, or your probable sources, and collect samples that will reveal whether they truly are sources or not.

So you would bracket your various land uses and your various activities, which could include your wastewater treatment plants; your urban areas with urban nonpoint source pollution; locations with high densities of cattle; locations with high densities of rural residential housing, septic systems; areas with a lot of road erosion; areas with streambank erosion, and on and on.

There are so many different possible source types. And a proper approach to evaluate that is to bracket those, collect samples above and below the locations of the sources. That's one tool that you can use.

But in terms of the overall sampling program for

the state, I just really didn't see much of that at all. It makes it very difficult to try to evaluate those sources.

Q. Based upon your review of the State's sampling program, did the State focus more closely on a particular source?

A. Yes, they did.

Q. What source, in your judgment, was the focus of the State's sampling?

A. The State's sampling was focused on their assumed linkage between poultry litter and water quality issues, especially phosphorus.

Q. What, if any, impact did that focus or that assumption have on the comprehensiveness of their investigation, in your view?

A. In my view, it wasn't comprehensive at all because there really was very little or, in some cases, no focus on these other issues in terms of where the samples would be collected.

Q. Doctor, as I understand it, one of the things you identified earlier as part of your work in this case is evaluation of potential sources; is that right?

A. That's right.

Q. And the court has heard some testimony from

Dr. John Connolly about potential sources and fate and transport. How is your analysis different from Dr. Connolly's, in a general way?

A. In a general way, Dr. Connolly, he focused a lot of work on Lake Tenkiller. I focused almost no work on Lake Tenkiller. He focused quite a lot on the issue of growing algae, that biological response, which is not something I addressed.

In terms of water quality, his work was mostly on point sources in the Illinois River and their influence on Lake Tenkiller and the influence of the total phosphorus on Lake Tenkiller. My focus was more on the entire watershed and looking at the -- some of the field issues and some of the more local issues for both point and nonpoint source pollution.

Q. Doctor, as part of your work in this case, did you review the mass balance analysis sponsored in this courtroom by Dr. Engel?

A. Yes, I did.

Q. What is your understanding of the role of this mass balance in the State's overall expert theory of the case?

A. My view is that the mass balance is very critical to the State's approach to the case.

Q. Doctor, is a mass balance analysis a tool that you have used in your work previously?
A. Yes.
Q. Can you explain what the concept of mass balance means to you.
A. Mass balance means balancing the inputs and the outputs to and from a system. You can construct mass balance on lots of different things.

For this case, the mass balance that was presented by Dr. Engel, calculated by Meagan Smith, was a mass balance on the watershed. So that would look at their estimates of phosphorus coming into the watershed and then phosphorus leaving the watershed primarily at this spillway at Lake Tenkiller.

But you can construct a mass balance on other things. You can construct a mass balance on the drainage water. And for the questions at hand in this case, I think the mass balance on the drainage water is really what's appropriate. What's going into the stream water, what's going into the lake water, what's coming out of the water, that's the mass balance that's really relevant to the case, in my view.
Q. Doctor, do you have an opinion as to whether

the State's mass balance is at all useful in evaluating potential impacts on water quality?

A. I think that a mass balance on the watershed can be of use. I don't really have a problem with somebody constructing one.

The problem I have is the way you use the results of that mass balance. And if you use that to try to say that because my mass balance says more phosphorus is coming into the watershed than is leaving the watershed, you know, therefore, that phosphorus is going into a stream, I think that's a big problem.

I can give you an analogy of that, if you would like.

Q. Sure.

A. If I built a warehouse in Fayetteville and I put 10 million tons of phosphorus in my warehouse and then lock the door, by the lines of argument that I've seen from the plaintiffs in this case, their conclusion would be, therefore, I'm polluting the Illinois River with phosphorus because I am the largest source of phosphorus coming into the watershed.

So it's mass balance on the water, on the drainage water in the stream and in the lake that's

really relevant to the case, not the mass balance -- out of the watershed.

Q. Doctor, you mentioned in your testimony previously land use. Did you evaluate land use in the Illinois River Watershed?

A. Yes, I did.

Q. Could you turn to tab 9 in your binder, please.

A. Yes.

Q. And find what's been marked as Defendants' Joint Exhibit 2238. And can you identify that exhibit for the record, please.

A. That's a map figure from my report.

Q. Okay. And was this map prepared under your direction?

A. Yes, it was.

Q. And can you identify the source of the land use data that is shown on this map?

A. It's the National Land Cover Dataset of EPA.

Q. Doctor, is that data shown geographically on this map?

A. Yes, it is.

MR. GEORGE: Your Honor, I move for the introduction of Defendants' Joint Exhibit 2238.

THE COURT: Any objection?

MR. BULLOCK: No objection.

THE COURT: Defendants' 2238 is admitted.

Q. (By Mr. George) Doctor, using this map, how would you characterize the land uses in the Illinois River Watershed?

A. I think that there are a couple of ways that I would characterize the land uses that are, in my view, quite important. The first one is, it's a patchwork of land use, it's a very interdigitated -- there's a lot of diversity of land uses across -- not the entire watershed, but many portions of the watershed.

Q. Let me stop you there, because you used a word that I'm not familiar with, "interdigitated." What does that mean?

A. If I take my fingers and I take my fingers where they do this, where they're inter -- my digits and put them together, that's -- sorry.

Q. In Arkansas, we could call that intermixed. Are you okay with that?

A. "Intermixed" is good.

Q. Same thing?

A. Same thing.

Q. Go ahead.

A. The other spatial issue that I think is

important is one that I actually mentioned before when I said that the watershed, in some sense, was upside down. And we can see that quite easily with this map because the top of the watershed is to the upper right, that's the main area, the headwaters, the main stem of the Illinois River. And then things move down to the lower portion of Lake Tenkiller.

As we can see on the map, most of the urban land is concentrated at the top, and then we have a fairly high density of agricultural land. And most of our forest land is more towards the bottom, which is the exact opposite of what we typically see.

Q. What impact, if any, does that reality in this watershed have on a scientist's ability to evaluate the impact of different sources of phosphorus?

A. It seriously messes with our ability to do that. The reason is because, as I mentioned before, the land use that's typically associated with your lowest phosphorus values is forest. That's almost universally true.

And at the top of the watershed, if you have urban land use, which is typically associated with one of the highest phosphorus contributors as a land use, and then you move to the agricultural

lands where you also can get more phosphorus than typically from the forest, so what happens is you get relatively high concentrations of phosphorus in the streams right from the beginning.

And that makes it difficult because if you start in the forest and you have low phosphorus, which you don't always, but often, then you move down and you start to pick up other sources, it's easier to identify those, along the lines of what I explained earlier of what I did in Tillamook.

When you start out with high values from the beginning and you've got things that are taking those values in different directions, you have new sources that are coming in at the same time that you maybe have phosphorus settling to the stream bed and that sort of thing. It makes it really difficult to figure out what the sources might be.

Q. Doctor, are you saying it's impossible to evaluate the impacts of different sources in this watershed?

A. No, it's not impossible. It's much more difficult, and it requires a lot more focus, in my view, on site specificity of your approach to tackling the problem.

Q. Doctor, are there sources, point versus

nonpoint, that due to the intermixing of land uses, are more or less difficult to identify in this watershed?

A. I would say that it's much more difficult to identify the nonpoint sources because of the distributed nature.

Q. Doctor, as part of your work in this case, did you evaluate impacts from urban areas in the watershed?

A. Yes, I did.

Q. I think you testified that the most significant urban areas are located in the headwaters; is that right?

A. That's correct.

Q. Did you evaluate the potential sources of phosphorus that are present in urban areas that may impact phosphorus concentrations in rivers and streams?

A. Yes.

Q. And I don't want to elicit -- I'm sorry, did you review Dr. Connolly's report and testimony that wastewater treatment plants are the dominant source of phosphorus that negatively impacts water quality in the watershed?

A. Yes.

Q. I don't want to elicit cumulative testimony, so let me step through this in a summary fashion, if I can.

Did you undertake a related analysis of the impact of wastewater treatment plants on water quality?

A. Yes.

Q. What did you do?

A. For the wastewater treatment plants, I did a couple of things. One is that I retrieved from Dr. Olsen's database for the state, data that he had and collected on the same day above and below wastewater treatment plants so we could compare the concentration of total phosphorus in the stream above the wastewater treatment plant, some couple of yards above the wastewater treatment plant or less, with comparable data collected a short distance below the wastewater treatment plant.

MR. BULLOCK: I object to this line of testimony. They said it's different than Connolly. My recollection of Dr. Connolly's is that this is exactly the analysis which he did was above and below.

THE COURT: At least part of it, I believe, was.

MR. GEORGE: There are some similarities in the sense that Dr. Connolly looked at water quality gradients. He did not do the analysis that Dr. Sullivan did, which was -- there were a couple of places -- I don't want to pre-empt the testimony, but there were a couple of places where we actually had paired bracketed samples on a few wastewater treatment plants.

THE COURT: I think Connolly testified to that, did he not?

MR. GEORGE: I believe -- and I'm happy to be corrected if my memory is incorrect -- that his analysis was more based on looking at stream segments and where one joins another as opposed to looking at two discrete sampling locations. This is very brief, and I don't want to be cumulative.

MR. BULLOCK: If it is brief, let's go ahead and do it rather than spend our time worrying about cumulative.

THE COURT: Go ahead.

MR. GEORGE: Thank you, Your Honor.

Q. (By Mr. George) Dr. Sullivan, did I just describe what you did in your analysis?

A. Yes. I was in the middle of answering the question as of what things did I do, and I had

briefly described one of them.
Q. Okay. Doctor, did you prepare a chart showing your analysis of the paired sampling locations for the few wastewater treatment plant locations?
A. Yes.
Q. Could you turn to tab 10.
A. Yes.
Q. And for the record, could you identify what's been marked as Defendants' Joint Exhibit 2240.
A. That's a figure from my report.
Q. And could you identify the source of the data and information that is shown on that figure or exhibit.
A. Dr. Olsen's master database.
Q. And was this exhibit prepared under your direction?
A. Yes.
MR. GEORGE: Your Honor, I'd move for introduction of Defendants' Joint Exhibit 2240.
MR. BULLOCK: No objection.
THE COURT: Exhibit 2240 is admitted.
Q. (By Mr. George) Dr. Sullivan, I notice that there are three facilities that are shown, Stillwell, Prairie Grove and Siloam Springs; do you see that?

A. Right.
Q. There are two bars associated with each of those facilities. What does that represent?
A. The orange bar represents the concentration of total phosphorus in the stream directly above the wastewater treatment plant outflow pipe location.
The blue bar represents that same total phosphorus location but immediately below the wastewater treatment plant location.
Q. And, Doctor, you understand there are more than three wastewater treatment plants in the watershed, correct?
A. Correct.
Q. Why did you focus your analysis on these three facilities?
A. These were the three facilities for which we had the data available for Dr. Olsen's database where -- on the same day he collected these samples. There were one or two other plants where I believe there was one, either the above or the below, but the corresponding data point was not there. These were the only three where we had both above and below.
Q. And, Doctor, did you form any opinions based upon your review of the sampling data above and

below these wastewater treatment plants?
A. Yes, I did.
Q. And what were those opinions or conclusions?
A. At all three sites, the concentration of total phosphorus in the stream water, all three sites above the wastewater treatment plants were all relatively low. They were in the vicinity of the .037 benchmark standard value.

And in all three cases, the samples collected below the wastewater treatment plant were substantially higher than that .037 standard.
Q. Based upon those observations, did you draw any conclusions about the impact of wastewater treatment plants on phosphorus concentrations?
A. Well, this indicates to me that these plants are important sources of phosphorus to the stream. And beyond that, that the quantity of phosphorus is actually quite high for two of them. The Siloam Springs one is over three milligrams per liter. That's an extremely high value of phosphorus.
Q. Doctor, these three facilities, do I understand that they actually have pipes that discharge into the river?
A. Correct.
Q. Is there any facility, wastewater treatment

plant or sewage treatment facility in the watershed that is not designed to be a discharging facility?
A. One that I'm aware of, yes.
Q. Which one is that?
A. It's at Watts.
Q. What type of sewage treatment system is present in Watts?
A. It's a total retention lagoon system.
Q. Total retention, does that mean, Doctor, that all of the wastewater and all of the phosphorus in that wastewater from the city of Watts stays in that lagoon?
A. No. The wastewater is periodically, after partial treatment, land-applied on a plot that's adjacent to the plant. It's sprayed on the plot.
Q. Are you familiar with the location of the Watts sewage lagoon and this application area that you just described?
A. Yes.
Q. And is it in close proximity to the Illinois River?
A. Yes, it is.
Q. Now, Doctor, as part of your work in this case, did you retrieve any aerial imagery of the Watts lagoons and the application area?

A. Yes.
Q. Can you turn to Defendants' Joint Exhibit 1454, please.
A. Yes.
Q. Can you identify for the record what is shown in the photograph in Defendants' Joint Exhibit 1454.
A. Yes, it's a figure from my report.
Q. And, Doctor, does this photograph accurately represent the location of the Watts lagoon in relation to the Illinois River?
A. Yes, I believe so.
MR. GEORGE: Your Honor, I move for introduction of Defendants' Joint Exhibit 1454.
MR. BULLOCK: No objection, Judge.
THE COURT: 1454 is admitted.
Q. (By Mr. George) Doctor, can you describe generally the features of this photograph and the facility that are important in the consideration of whether it would be a potential source of phosphorus.
A. Well, on the photograph, the land area that's above the three-basin lagoon system, the area above that is -- where you see circles on it, that's the irrigation area where the wastewater is applied to

the land periodically. And then the dark line across the top from left to right, that's the main stem Illinois River Watershed close to the bridge at Watts.

Q. Doctor, has the Watts facility been identified as a potential source of nutrients to the Illinois River?

A. Yes. They've had some problems at the facility. There was one instance that was documented by Dr. Ron Jarman for the defendants, and he provided to me a copy of some of the documentation of that, where the City of Watts was actually fined for leakage and improper distribution of the water, a problem that they had at the site.

Q. Do you know approximately how close the irrigation field for this lagoon system is to the Illinois River?

A. It's about a hundred feet, more or less.

Q. Doctor, did any of the State's experts offer any analysis of the potential impact on phosphorus levels in the Illinois River from the Watts sewage lagoons?

A. Nothing that I saw.

Q. Based upon the data that you've reviewed, should this potential source have been considered

and evaluated?
A. Yes.
Q. Doctor, did you review any data regarding sewage bypasses at point source facilities in the watershed?
A. Yes.
Q. For the benefit of the record, just briefly, what is a sewage bypass and how can it introduce phosphorus?
A. A sewage bypass can occur from a number of different problems in a wastewater treatment system, but it's a situation whereby raw sewage or partially treated sewage is accidentally released. So it can be released by a broken pipe or a broken pump station or excessive rain overwhelming the system.

There are different ways that bypasses can occur, but it will introduce either raw or partially treated sewage into the environment, which may or may not flow into a stream.
Q. Doctor, would that be phosphorus that is in addition to what comes out of the pipe of the facility that is reported that we've had a lot of testimony about?
A. Correct.
Q. Doctor, there's some evidence in the record of

this case regarding sewage bypasses. And I don't intend to take you through all of that for -- out of respect for the court's time. But based upon the data and information that you've reviewed, are the sewage bypasses a potentially significant source of phosphorus?

A. Well, they're certainly a potential source.

Q. Did any of the State's experts offer any analysis of the potential impact of sewage bypasses on phosphorus levels in the Illinois River?

A. Nothing that I saw.

Q. In your opinion, should that source or potential source have been considered?

A. Yes.

Q. Now, Doctor, you're familiar with Oklahoma's scenic rivers criterion of .037?

A. Yes, I am.

Q. And do you have some understanding or familiarity as to which stream segments that standard applies to in the Illinois River Watershed?

A. Yes, it's the scenic rivers.

Q. Did you prepare -- let me ask this question first, Doctor. As part of your work in this case, did you identify the discharge locations of all of the wastewater treatment plants?

A. Yes.
Q. Is there any scenic river stream segment in the Illinois River Watershed that is not downstream from one or more of these discharging wastewater treatment plants?
A. No.
Q. Did you prepare some demonstratives to illustrate that?
A. Yes, I did.
Q. And could you turn to tab 12.
A. Yes.
Q. For the record, could you describe what is Tyson Demonstrative 60.
A. It's a map of the Illinois River Watershed. The larger streams are outlined in red from the locations of the wastewater treatment plants which are represented by the triangles, and it shows the flow path. The red lines would be the flow path of water down the streams from the locations of the wastewater treatment plants to the location of Lake Tenkiller.
Q. Doctor, could you turn to the next tab which has been marked as Tyson's Defendant Demonstrative 61. Did you prepare this demonstrative?
A. Yes.

Q. Could you identify the information that is illustrated on that demonstrative.
A. It shows the locations of the designated scenic rivers: Barren Fork, Illinois River, and Flint Creek.
Q. And so, Doctor, does comparing these two demonstratives that we just looked at illustrate the statement that you made regarding scenic rivers all being downstream of wastewater treatment plants?
A. Yes, it does.
Q. Now, Doctor, is it your testimony that point sources or wastewater treatment plants are responsible for every elevated phosphorus measurement in the watershed?
A. No.
Q. Why not?
A. Well, there aren't many other sources besides the point sources. There's a whole body of science out there on the importance of nonpoint source pollutants. We know they're there, and they're very well distributed throughout this watershed.
Q. Based upon your experience, training and the data that you've reviewed, Doctor, as part of your work in this case, what might cause an elevated phosphorus measurement not downstream of a

wastewater treatment plant?
A. Well, I think to answer that, I really need to back up and split it into two segments. One would be the nonpoint sources associated with the urban areas, and the other would be the nonpoint sources associated with -- for this watershed, with the agricultural areas in particular and, to a lesser extent, the forested areas.

So for the urban areas, we have a variety of nonpoint source pollution sources in urban areas. The thing that's really important about evaluating nonpoint source pollution in urban areas is the effect of people's building activities and other activities on the hydrology, on how the water flows in the urban areas.

In particular, you have a large -- relatively large percentage of the urban land use is occupied by what's called impervious area, or compacted soils. And the impervious area would be the areas like rooftops, driveways, sidewalks, streets, parking lots, all the places where when it rains, the water cannot infiltrate into the soil.

Then the compacted soils, you see a lot of that in conjunction with construction activities. So the more land disturbance and construction that

you have in the urban area, the more likely you are to have these compacted soils. And they can be impervious or semi-impervious.

But the key point is that when it rains and the water hits these areas, it's not able to infiltrate into the soils. And it can pick up all kinds of sources of phosphorus in the process of moving before it gets into a stream. So it can pick up a lot of dust, it's wind blown and small soil particles that have phosphorus adsorbed to them. There's the waste of pets and wildlife. There's fertilizer use.

So there are all these sources of phosphorus in -- there's breakage in the sewer line system, small leaks, large leaks, you know, accidents. But there are all these sources of phosphorus that are there from people and their activities and their pets. And the fact that so much of the surface is impervious provides an opportunity to move that water directly into a stream without the opportunity for the soil to pull the phosphorus out as the water moves down through it.

And this is especially complicated by the infrastructure that we install in our cities to deal

with rain water. We don't want the streets to flood, that's a problem. So we build storm drains and we build ditches and gutters and all kinds of systems to efficiently route the rain water away from our cities and into the streams.

Q. Doctor, let me ask a question. Mr. Bullock was about to pinch me. He wanted me to interject some questions to break this up, I think.

With respect to rural areas, are there multiple potential sources located in rural areas in this watershed?

A. Yes, very much so.

Q. Do you believe, Doctor, that the causes of elevated phosphorus measurements in the Illinois River Watershed can be evaluated, estimated or quantified on a watershed-wide basis with respect to nonpoint sources in particular?

A. No, there are too many and they're too distributed. They tend to be small. They're all over the watershed. You need a site-specific assessment to really sort that out.

Q. Now, Doctor, as part of your work in this case, did you review data and spatial patterns to attempt to identify potential nonpoint sources of phosphorus in the watershed?

A. Yes, I did.
Q. And could you please describe what it is you reviewed in that regard.
A. Well, I think the main thing that I reviewed would be the data from Dr. Olsen's database on the Illinois River Watershed. And I looked at the concentrations of phosphorus at different locations within the watershed.
Q. Did you review information regarding the number and location of mammals, including humans?
A. Yes, I did.
Q. Did you review comparable information for livestock such as cattle?
A. Yes. The first one when you said mammal, so that would have been the humans and the cattle would be the two types of mammals.
Q. Good point. That's always been tricky for me.
Doctor, did you review Dr. Fisher's testimony in this court that the current human population in the watershed is approximately 300,000?
A. Yes.
Q. Is that consistent with the human population data that you reviewed?
A. Yes, it is.

Q. Could you turn in your binder to tab 14, please.
A. Yes.
Q. And find Defendants' Joint Exhibit 2280.
A. Yes.
Q. Could you identify Exhibit 2280 for the record, please.
A. That's a table from my report.
Q. And there is some human populations shown on that table; is that correct?
A. That's correct.
Q. Can you identify the source of the population estimates or data that is shown in Exhibit 2280.
A. The data for 1990 and 2000 are from the U.S. Census. The data from 2007 are data that are provided by ESRI, E-S-R-I, which is the group that produces the main Geographic Information System computer software that's used to analyze spatial data and environmental sciences. So they will model census data in the interim in between census periods. So the 2007 data is ESRI's model estimates to the population.
Q. Doctor, are both of these datasets that you described, the census data and the ESRI data, datasets that are commonly used in environmental

investigations?
A. Yes.
Q. Doctor, you've provided these estimates by the watershed. Does the U.S. Census or the ESRI group maintain population estimates by watershed?
A. No.
Q. So what did you do with respect to taking the data from those two sources to arrive and compile it into a figure that is representative, in your view, of the population in the watershed?
A. Okay. The census data are provided by what's called census block groups, small units. And so what we did was to look at the population in each census block group that occurred wholly within the IRW. And we added those up.

And then we took the census block groups that were partially in and partially out of the boundary of the Illinois River Watershed, and we computed the percentage of the block group that was inside the watershed and multiplied that by the population for that block group, and that gave us the estimate of the human population in the portion of the block group that was within the IRW. And then we added them up.

MR. GEORGE: Your Honor, I'd move for

introduction of Defendants' Joint Exhibit 2280.

MR. BULLOCK: No objection, Judge.

THE COURT: Not going to step on you this time, Mr. Bullock. 2280 is admitted.

MR. GEORGE: Notice I got out of the way, Judge.

Q. (By Mr. George) Dr. Sullivan, for benefit of the record, what does this analysis show as to the human population in the watershed from 1990 to 2007 and how it has changed over time?

A. There's been a very rapid increase in the human population. Actually, northwest Arkansas, which includes that upper region of the IRW, has been called one of the fastest-growing metropolitan areas in the United States in recent years. But the increase has been quite dramatic. Just within the decade of the 1990s alone, the human population increased by more than 40 percent, based on these census estimates.

Q. Doctor, if we compared the change from 1990 to 2007 -- I'm by no means a mathematician -- but would it be a growth greater than 40 percent, I assume?

A. Actually, I don't think I've done that calculation. I mean, the numbers that we can really have the greatest confidence in are the actual

census numbers for 1990 and 2000. That was more than 40 percent. But clearly the increase has continued unabated and it's been a very large change over a fairly short period of time.

Q. Thank you, Doctor. Doctor, how was the information regarding -- I'm sorry, let me move to the next exhibit. Turn to tab 15, please.

A. Yes.

Q. Could you find Defendants' Joint Exhibit 2239.

A. Yes, I have it.

Q. And for the record, could you identify what is Defendants' Joint Exhibit 2239.

A. It's a figure from my report.

Q. Was this figure prepared under your direction?

A. Yes, it was.

Q. What's the source of the data that is shown in this exhibit?

A. That would be the same as the previous exhibit.

MR. GEORGE: Your Honor, move for the introduction of Defendants' Joint Exhibit 2239.

MR. BULLOCK: No objection.

THE COURT: 2239 is admitted.

MR. GEORGE: Thank you, Your Honor.

Q. (By Mr. George) Doctor, how was the information that we've just looked at in terms of the size and

the location of the human population in the watershed important to your identification and analysis of potential nonpoint sources?

A. Well, it's very important, because the -- in terms of the nonpoint source contributions from urban areas, it's not just the size of the urban area or the population in the urban area that's important; it's also the development that's taking place.

And the reason for that is because where you have a lot of land-disturbing activities, that provides the opportunity to move more phosphorus and other constituents as well from those areas to the streams along nonpoint source flow paths.

And the reason is because in the process of disturbing the lands when you're digging things up for construction, you've got equipment working there, you're compacting soils and you're disrupting, you're expanding from areas that were not impervious to make them impervious and introducing all the disturbance at the same time.

That generates a lot of opportunity for erosional contributions to the streams, and erosion involves the movement of soil particles, many of which are small. And the smaller they are, the more

likely they are to transport phosphorus adsorbed to them.

Q. Doctor, what does Defendants' Joint Exhibit 2239 show about the location of this growing human population and urban development in the watershed?

A. Well, it shows what I think is pretty common knowledge within the watershed, and that is that most of the development in recent years has been concentrated in that upper portion of the watershed basically between Rogers and Fayetteville, and to some extent, around Tahlequah as well in Oklahoma.

Q. Doctor, you've identified some of the things that occur within urban areas that can impact nonpoint source phosphorus. I don't believe you've yet mentioned commercial fertilizer. Can commercial fertilizer use in urban areas have an impact?

A. Yes, it can.

Q. How so?

A. Well, it's the same kind of issue. In these urban areas, there are lots of opportunities to short-circuit the process of water moving down into the soil, infiltrating into the soil, where you provide the opportunity for phosphorus to be adsorbed to the soil particles and remain in the soil as opposed to passing into the stream.

So where you have a lot of lawn fertilizing in conjunction with sprinkler systems that are adjacent to sidewalks and the rest of it, you're just providing an enhanced opportunity for phosphorus that people place on the land in this urban environment, and when it rains hard, especially coupled with sprinklers or even independent of the rain, just the sprinklers, you have the chance of moving this water with phosphorus into the conduits that run directly into the streams without the opportunity for soil interaction.

Q. Dr. Sullivan, the court has been treated with some analysis of urban development by Dr. -- or by Wayne Grip. Are you familiar with Wayne Grip?

A. Yes.

Q. I'm told that His Honor even donned some 3-D glasses, and I wasn't here to see it, which is regrettable.

Did you also review Mr. Grip's analysis of aerial photographs in this corridor in northwest Arkansas of urban development?

A. Yes, I did.

Q. How was that information useful to you in your analysis of potential nonpoint sources?

A. Well, it was useful to just reconfirm what the

other analyses were suggesting, that there's been a large increase in the human population and in the amount of development in the upper watershed. And it is the same thing I could see visually when I toured the upper watershed myself. There was a lot of construction going on.

Q. I've been given -- handed a note that I did not ask you about cats and dogs. And --

THE COURT: Or Tontitown.

MR. GEORGE: Or Tontitown, which I'm going to stay away from for personal reasons.

Q. (By Mr. George) Dr. Sullivan, did you review any information to try to get a handle on how many cats and dogs there are in the watershed?

A. Yes, just a rough estimate. I used national figures of how many dogs and cats per household and number of people per household and did some simple mathematics. And based on national numbers, if the people who live in the IRW have pets at the same rate as people elsewhere in the country, then there are -- it was over 400,000 cats and dogs.

And the reason that's important is not so much because it's 400,000 cats and dogs; it's because they're going to be concentrated where the people are. And so many of these cats and dogs are

going to be in these urban environments.

It's the same issue is that if you put fecal material from a pet in a place where your lawn sprinklers and the rain can move that quickly and easily into the flow system independent of the soils, then you've got significant opportunity to transport the phosphorus and other things that are contained in that fecal material into a stream.

If the water takes it down into the soil, then you expect most of that phosphorus or all of that phosphorus to be adsorbed. But in an urban environment, there is much less opportunity for that to happen.

THE COURT: You're not offering a comparison between the contribution of nonpoint source phosphorus from cats and dogs relative to poultry, are you?

THE WITNESS: No, sir, I'm not. What I'm doing is just trying to indicate that in the urban environment, there are many, many sources. And because of the hydrology of the urban environment, there's a dramatically enhanced opportunity to move any or all of them into a stream; whereas, in the pasture environment -- not everywhere, but in general, when it rains, the water infiltrates into

the soil, and you have that soil contact.

THE COURT: We did broach a new subject here after four months.

MR. GEORGE: Absolutely.

Q. (By Mr. George) What you're saying, Dr. Sullivan, is if a delightful young man who lived in Tontitown, owned four large Golden Retrievers, that I might be a potential source?

A. I suppose it's possible.

Q. Okay. Doctor, did you conduct a spatial analysis of water quality in association with the urban areas that we've been discussing?

A. Yes, I did.

Q. And tell us generally how you went about that spatial analysis.

A. Well, I looked at the data from Dr. Olsen's database and plotted the locations throughout the watershed, including around the urban areas, of the total phosphorus that was measured in the samples. And, again, I used a geomean of five or more samples to represent individual locations.

Q. Did you prepare any figures for your expert report demonstrating this analysis?

A. Yes.

Q. And could you turn to tab 16 in your binder,

please.
A. Yes.
Q. And could you -- actually, let's take them in a group, if we can. Could you look at Defendants' Joint Exhibit 2244, which is behind tab 16, and Defendants' Joint Exhibit 2245. Do you see both of those?
A. Yes, I do.
Q. Can you identify those documents for the record, please.
A. Yes. Those are figures from my report.
Q. Okay. Were these figures prepared under your direction?
A. Yes.
Q. And generally, can you describe the data or information that is illustrated or shown on these figures?
A. Well, in both cases, it would be data from Dr. Olsen's database in the IRW. Five or more samples reported as a geomean for each location where we had five or more samples.
The difference between the two maps is the first one shows all of his data regardless of the flow condition, and the second map shows his data for the sampling occasions for which he classified

the sample as a base flow sample when it was not an elevated flow because of a rainstorm, for example.

Q. Doctor, to be clear, the data that is represented is phosphorus data; is that right?

A. Total phosphorus.

Q. And there are bars on here. Do the heights of the bars correspond to concentrations of phosphorus?

A. Yes, it's the same style of presentation as those Oklahoma maps we looked at earlier, that the bars are colored green if they're below the .037 standard. I believe -- yes, and then they're colored orange if they're above. And the height is proportional to the concentration. And there's a scale bar that shows you the height of a bar that would be at a concentration of 0.5 milligrams per liter of total phosphorus.

MR. GEORGE: Your Honor, I move for introduction of Defendants' Joint Exhibit 2244 and 2245.

THE COURT: Any objections?

MR. BULLOCK: No objection.

THE COURT: 2244 and 2245 are admitted.

THE WITNESS: I apologize, Mr. George. I was explaining what was there, and I neglected to say something important. The municipal boundaries

are also indicated and the locations of the wastewater treatment plants on the figure -- on the map as well.

Q. (By Mr. George) Why is that information important to your analysis?

A. Well, the question was to what extent was I looking at the potential involvement of the urban areas in the transfer of phosphorus to streams. So for that, we want to look at both the point and the nonpoint source components of that.

The point source would be the wastewater treatment plants, and the nonpoint would be the municipal boundaries.

Q. Doctor, on both of these maps, I notice that there's a bar that's visible, and it's high in comparison to some of the bars on this map right in the middle of the watershed. Do you see that?

A. Middle top?

Q. Actually, middle-middle. Let me approach it this way. Are you familiar with the location of the Westville wastewater treatment plant?

A. Yes.

Q. And is that shown on both of these maps as a triangle?

A. Yes, that's a good point. It's hard to see

behind the bar, isn't it? It's there.
Q. Just so we're clear, could you go to the map and just point that location out one time, because it is hard to see the triangle.
A. Right there. (Indicating.)
Q. Now, Doctor, what conclusions, if any, do you draw from your spatial analysis of phosphorus concentration downstream from urban areas?
A. There's a very strong pattern in Dr. Olsen's data. And we see the same pattern with both -- considering all flow conditions and also in considering just the base flow conditions.

But the pattern is that the highest bars on the map, which correspond with the areas that have the highest total phosphorus concentrations expressed as a geomean of multiple samples, but those are very strongly associated with both the urban area locations and also the wastewater treatment plant outflow locations.

We don't have the data that would really allow us to separate out those two very effectively because the data don't bracket the urban areas independent of wastewater treatment plants. So it's difficult to tease it out.

Based on other analyses, our expectation is

that much of the phosphorus there is coming from the point source. But we don't really have a good way of estimating how much additional phosphorus is coming from the urban nonpoint source.

But the spatial pattern is very clear that the high bars are uniformly downstream from the urban areas and wastewater treatment plants.

Q. Doctor, do you see that same spatial analysis or association even when you look at Defendants' Joint Exhibit 2244, which you described as having data from all flows, high flows and low flows?

A. Yes.

Q. Now, Doctor, did you review Dr. Jan Stevenson's testimony in this courtroom that urban land use results in a large increase of total phosphorus in streams in the Illinois River Watershed?

A. Yes, I remember that.

Q. Was that testimony consistent with your own observations and conclusions?

A. It is.

Q. Now, Doctor, based upon the data and information that you have reviewed, are urban areas a significant enough potential source of phosphorus that they should have been considered in an investigation of causes of phosphorus loading to the

Illinois River Watershed streams and rivers?

MR. BULLOCK: Leading.

THE COURT: Sustained. Rephrase.

MR. GEORGE: Your Honor --

Q. (By Mr. George) Dr. Sullivan, did you see any meaningful analysis of urban areas in the expert testimony and reports put forward by the State's experts?

A. There were analyses that were done that they considered point sources. I didn't see any analyses that really addressed the nonpoint component of the urban contribution, and I didn't see pairs of samples that would allow me to do that investigation either. So the data simply were not collected in such a way to allow an investigation of urban nonpoint sources.

Q. Should urban nonpoint sources have been considered in the investigation and evaluation?

A. Definitely.

Q. Now, again, Dr. Sullivan, are you testifying that all elevated phosphorus readings in the watershed correspond to urban areas?

A. No.

Q. Let's move away from urban areas and talk about some potential nonurban impacts on water quality.

You mentioned erosion from construction sites. Are there other forms of erosion that we might see even in rural settings?
A. Yes.
Q. Could you describe those, please.
A. The most important ones would be erosion associated with roads, and that's most pronounced for unpaved roads, for dirt roads.
Q. Did you say unpaved roads?
A. Unpaved. So the dirt roads -- the roads in general are well known as significant sources of phosphorus -- of erosion, and the dirt roads in particular.

The other source that would be particularly important, or the second source, would be streambank erosion, of which there's quite a significant amount in this watershed.

Then finally, erosion associated with other land-disturbing activities. And in the nonurban environment in a watershed like the IRW, there's really not much row cropping. That's a major issue in many places. There's not too much of that in the IRW. There's some.

But the other issue is activities of the livestock of removing vegetation and trampling the

soil and disturbing the soils. So there can be erosion associated with that.

Q. Have you worked on erosion-related water quality issues outside of this lawsuit?

A. Yes.

Q. Could you describe when you had those experiences.

A. We address erosion -- it's an important part of all of our watershed assessments. Erosion is a big issue with respect to aquatic habitat health, fisheries, water quality, riparian zone integrity. So there are many aspects of erosion that are important.

It's always an analysis that we do in our watershed assessments, watershed analyses for federal agencies and for watershed councils.

Q. I didn't mean to interrupt you.

A. Well, I've done some other research on it myself as well.

Q. Go ahead. I'm sorry.

A. In some of the Tillamook studies that I described earlier where we collected samples at the forest/ag interface and then at the base of the rivers before they flowed into the bay, that forest/ag interface represented a nice transition in

the watershed where, above that, there was no agriculture, there were no urban areas, there was almost no rural residential housing. It was just forest.

And the sources of erosion and phosphorus, which was one of our main interests in that, were really from two things: From logging, which was prevalent, but was not excessive, and from logging roads, dirt roads, which were very commonplace. And that -- so we did analyses on evaluating --

MR. BULLOCK: I object to the relevance of this. It doesn't appear to have -- it's certainly not responsive to the question, and it doesn't appear to have any relevance to the matter we're talking about.

THE COURT: Sustained. Mr. George.

Q. (By Mr. George) Dr. Sullivan, is it generally recognized that erosion from dirt roads and streambanks contains phosphorus?

A. Yes, it is.

Q. Have you seen any reports from Oklahoma agencies discussing erosion as a source of phosphorus in the Illinois River Watershed?

A. Yes, I have.

Q. Doctor, have you yourself personally seen any

evidence of substantial amounts of streambank erosion, for example, occurring in the watershed?
A. Yes, I have.
Q. Could you please describe that and how it was that you came to see it.
A. I saw it really three ways. The first would be on a canoe trip that I took with a group of defense lawyers and experts.
MR. BULLOCK: Judge, I think this is cumulative of our video highlights of the other day of streambank erosion.
THE COURT: I think this is cumulative. Sustained.
MR. GEORGE: Your Honor, and I'll proceed and see how it goes. But just for the benefit of the court, there is a photograph that was taken that I would like to move into evidence. I do appreciate there is some evidence in the record, so I'm going to attempt to do that. And if Mr. Bullock objects and you sustain it, I'll move on, of course. But I want you to appreciate that I did hear Your Honor.
Q. (By Mr. George) Dr. Sullivan, could you turn to Exhibit 18.
A. Yes.
Q. And you'll find -- I'm sorry, tab 18, which has

been marked as Defendants' Joint Exhibit 633-0031, 633-0055, 633-0072, 633-0075, and 633-0089, 633-0015.

Dr. Sullivan, do you recognize those photographs?

A. Yes, I do.

Q. Were you present when they were taken?

A. Yes, I believe so.

MR. GEORGE: Let me correct something for the court's benefit. Which one did I invert, Mr. Todd?

I'm told I can't read numbers, Your Honor. The last one is actually 633-0105. My apologies.

Q. (By Mr. George) I'm sorry, Doctor. Were you present when these photographs were taken?

A. Yes.

Q. Were they taken on a float trip along the Illinois River?

A. Yes.

Q. Did you personally observe the streambanks that are shown in these photographs?

A. Yes, I did.

MR. GEORGE: Your Honor, I move for the introduction of those previously identified exhibits.

MR. BULLOCK: While cumulative, we're not going to object.

THE COURT: Very well. Those exhibits are admitted. Mr. George.

MR. GEORGE: Thank you, Your Honor.

Q. (By Mr. George) Doctor, do those photographs show eroded streambanks?

A. Yes, they do.

Q. Doctor, based upon your floating of the Illinois River, are the conditions shown in those photographs common or uncommon along the stretch that you've at least been exposed to?

A. Well, I wouldn't say that the entire stretch is eroded to this extent, but the levels of erosion that we see here are quite commonplace throughout the stretch of river that we canoed. And I could observe similar conditions from a flyover that I did in the watershed as well.

Q. Doctor, would you expect streambank erosion to contribute phosphorus to streams during high flow or base-flow conditions?

A. Primarily high flow.

Q. Now, the court has heard about these pulses of phosphorus that move through the stream and river system during high flow or runoff conditions. Would

that pulse include phosphorus from eroded streambanks?
A. Yes.
Q. Now, in addition to introducing phosphorus, can erosion and, for that matter, resuspension of sediment material have any other harmful impacts on water quality?
A. Yes.
Q. What are those?
A. It increases siltation, so buildup of sedimentary materials. In Lake Tenkiller, for example, and other impoundments in certain areas of the stream system, it increases turbidity, can have a detrimental effect on various life forms. For some fish, there's spawning beds, for example, that would -- for some fish, it's gravelly areas, and if you fill those in with fine sediments from erosion, that can degrade the spawning habitat. Same thing for some of the insects that provide food for the fish.
Q. Doctor, can erosion have any impact on the color or the appearance of water during high-flow events?
A. Yes.
Q. There's been some testimony in this case and

photographs shown of brown water during high-flow events. Have you seen that?
A. Yes, I have.
Q. Is that a common result of erosion?
A. Yes. Erosion -- and the color is going to depend on the color of the soil particles that are eroded. So I've seen rivers and streams that look red in color as a consequence of erosion, and others look brown, and some look tan. And I mean, it really depends on what the soil is. But it can impart a substantial color and make it so that you can't see through very much of the water column.
Q. Now, Doctor, you also mentioned erosion from dirt roads. What is it about dirt roads that makes them a potential source of phosphorus to streams?
A. Several things. One is that when you have a lot of roads and you have a lot of streams, they cross each other. Where a stream crosses a road, typically you have a culvert. I mean, if it's a large stream and a large road, it's typically a bridge. For the most part, we're talking about a culvert.

Also, roads tend to have ditch lines that run parallel to them to carry the water away so they don't flood. If a lot of water moves to those

ditches, sometimes there's no vegetation in them which makes the soil in the ditch more erodible.

The road surface is impermeable or relatively impermeable and, therefore, dust blown from adjacent fields or from anywhere that accumulates on the road when it rains can be washed into the ditch and through the culvert and carried, if it flows into a stream -- which it may or may not -- carry the materials into that stream.

So it's a case of the locations of the roads relative to the streams and the setting in which the road is placed will determine the extent to which that's going to happen, but it's a very well-understood phenomenon.

Q. Did you review any data or information to determine the degree to which dirt roads are present in the watershed?

A. Yes, I did.

Q. And what information did you review?

A. U.S. Census TIGER files that have the road distribution information.

Q. Doctor, based upon your review of that data, can you provide the court with any information that would put into perspective the magnitude or mileage of dirt roads in the watershed?

A. It's over 5,000 miles of road in the Illinois River Watershed. 5,100-something miles of road in the watershed. It's close to half and half between Oklahoma and Arkansas, a little bit more in Arkansas, I think.

And then we have -- for the Arkansas side, we have data to tell us which ones are paved and which ones are not paved. We don't have that for the Oklahoma side.

Q. What percentage was paved in Arkansas?

A. About half.

Q. Half of the -- the total number was for the watershed, 5,000, right?

A. Yes. So the total amount of unpaved road in Arkansas was around 1,300 miles. And then it's probably a somewhat similar number for Oklahoma.

Q. Okay. Now, Doctor, based upon the data that you've reviewed, is erosion from streambanks and dirt roads a significant enough potential source of phosphorus that it should have been considered in the investigation in this case?

A. Yes.

Q. Was it considered by the State's experts, based upon your review of their work?

A. No.

Q. Now, let's talk about septic systems. Did you evaluate the extent to which the human population in the watershed is serviced by septic tanks as opposed to wastewater treatment plants?
A. Yes, I did.
Q. And did you review Dr. Engel's testimony in this courtroom that there are approximately 73,000 septic tanks in the watershed?
A. Yes.
Q. And is that consistent with the data that you reviewed?
A. Yes, it is.
Q. Doctor, did you include in your report any data regarding the use of septic systems in the IRW?
A. Yes.
Q. Can you turn to tab 19 in your materials --
A. Yes.
Q. -- and find Defendants' Joint Exhibit 2279.
A. Yes.
Q. Can you identify that exhibit for the record, please.
A. That's a table from my report.
Q. And, Doctor, was this table prepared under your direction?
A. Yes.

Q. And could you identify generally the source of the data and information that is shown in this table.

A. The human population data were taken from the U.S. Census. And then for the various municipalities, Ron Jarman did an analysis of wastewater treatment plant point sources for the defendants, and he reported to me which ones of these communities were on centralized wastewater treatment systems.

The reason for that is if a community is not on a centralized system, then people are using septic systems for the most part.

Q. Did you then take that data and try to remove from the overall human population those that are serviced by wastewater treatment plants to arrive at a number?

A. Correct.

Q. What did your analysis show as to the use of septic systems in the watershed?

A. Well, it certainly varies by the municipality, but overall I came up with an estimate of a little over 76,000 people in the watershed on septic systems.

MR. GEORGE: I'm sorry, Your Honor, I

failed to move to introduce this. At this time, I'd offer Defendants' Joint Exhibit 2279.

THE COURT: Mr. Bullock.

MR. BULLOCK: No objection.

THE COURT: 2279 is admitted.

MR. GEORGE: Thank you.

Q. (By Mr. George) Doctor, can septic tanks deliver phosphorus to groundwaters and surface waters?

A. Yes, they can.

Q. Is there one that they're more likely to impact than the other?

A. It really depends. Again, it's a site-specific thing. It's going to depend on whether or not the septic system is causing a problem and, if it is, what the nature of that problem is and where it's located.

Q. Do septic systems have to be malfunctioning to contribute phosphorus to groundwater or surface water?

A. Well, I would say that certainly for surface waters, if they're not malfunctioning or improperly located, then it's not likely that they're contributing much or at all. But the problem is if they're not placed in the proper locations or

they're malfunctioning, then there is a possibility of contributing to some stream waters.
Q. What about groundwater; can a septic system, even if it's not malfunctioning, contribute phosphorus to groundwater?
A. Well, again, the answer is it depends. It's going to depend largely on the depth of the soil and the depth of the location of the lateral lines of the septic system. And that's going to depend to a large degree, I would assume, on when the system is built and if it was built to proper specifications or not. So in that instance, we're probably looking at more of a malfunctioning issue.
Q. Doctor, based upon the information and data that you reviewed, are septic tanks a significant enough potential source of phosphorus that they should have been considered?
A. I certainly think that they should have been considered, yes.
Q. Did you see any meaningful analysis of phosphorus from Illinois River Watershed septic tanks and the works completed -- and the work completed by the State's causation experts?
A. I saw some analyses and some discussion that addressed septic systems, but I saw nothing there

that I considered to be meaningful.
Q. Did you review the work of Dr. Engel and Dr. Cox on their correlation analysis of phosphorus concentrations with certain things?
A. Yes.
Q. And did you find in that work any information relating to septic tanks as a potential source?
A. Yes.
Q. What did you find?
A. Well, they reported a statistically significant correlation between the density of septic systems across the landscape in their 14 small watersheds that they studied. So it's a correlation between septic system density and phosphorus concentration in the stream. They found a significant correlation between those two variables.

They dismissed that as an artifact of another correlation that they found with poultry house density, but there was no adequate basis for that dismissal, in my view.
Q. Doctor, you mentioned cattle as another potential source of phosphorus earlier. Did you review data on the extent and location of cattle in the watershed?
A. Yes.

MR. GEORGE: Your Honor, this is another area where I appreciate the court has been exposed to some information by Dr. Clay on cattle, and I don't intend to repeat any of his testimony, but Dr. Sullivan has taken some of that information and mapped it so that we can have benefit as to where those cows are located generally. With that understanding, I'm going to proceed.

Q. (By Mr. George) Dr. Sullivan, did you review Dr. Clay's testimony regarding his calculation that there are approximately 200,000 head of cattle in the watershed, and those cows deposit approximately -- manure containing approximately 3,100 tons of phosphorus per year?

A. Yes.

Q. How, if at all, are cattle important to your analysis of potential nonpoint sources?

A. Well, they're very important by virtue of the size of the cattle population coupled with the ways in which cattle behave and the locations in which you find cattle. So they're very important.

Q. Let's talk about location. Did you examine data showing cattle concentrations across the state of Oklahoma so that we could have some context as to whether this is a high or a low density cattle

area?
A. Yes.
Q. What was the source of the data that you looked at in that analysis?
A. The Oklahoma 2002 Census of Agriculture.
Q. And could you turn to tab 20.
A. Yes.
Q. Find Defendants' 2250. Could you identify that for the record, please.
A. That's a figure from my report.
Q. And is the USDA census data for the state of Oklahoma that you just described shown graphically on that exhibit?
A. Yes. It's shown graphically as cattle density by county.
Q. Was this figure or exhibit prepared under your direction?
A. Yes.
MR. GEORGE: Your Honor, I move for the introduction of Defendants' Joint Exhibit 2250.
MR. BULLOCK: No objection.
THE COURT: 2250 is admitted.
Q. (By Mr. George) Doctor, what conclusions, if any, did you reach based upon your review of this information?

A. That the density of cattle across Oklahoma exhibits certainly some variation. But the IRW location is shown with the black line around the watershed there to the right. And what that indicates is that the density of cattle in the IRW is relatively high or moderate compared to the rest of the state. It's certainly not lower.

Q. Using the key in the left-hand corner for the benefit of the record, could you identify the cattle density by square mile in the counties that are comprised within the Illinois River Watershed.

A. Yes. For much of it, it's between 100 and 150 cattle per square mile. For the lower section, it's a little bit lower than that.

Q. Now, Doctor, I believe you testified to this earlier, but if not, I want to make sure. Have you been involved in the past in any scientific studies on the impact of cattle and cattle manure on water quality?

A. Yes.

Q. Does that relate to the work that you conducted in Oregon watersheds?

A. Yes.

Q. And the BMP project that you discussed earlier?

A. That's correct.

MR. GEORGE: Your Honor, with the court's indulgence, we have a physical model that I would like to use with this witness. And I by no means want to be condescending to the court. I appreciate that the court has some familiarity with cattle and cattle operations and probably has a grasp on much of the impacts. And this particular model was prepared at a time when we believed we might have a jury. But I think it might be useful to spend a few minutes with the witness just talking through, with that as a framework, his opinions regarding cattle and the potential impacts.

THE COURT: I've not seen this. Will it really be helpful, Mr. Bullock?

MR. BULLOCK: I've got an objection to principle on this. I don't think it's very helpful. But my principle is this: Clearly this model was prepared -- this diorama, as they call it, was prepared well in advance of this trial, as counsel says. We didn't receive notice of this until a quarter of ten on Saturday night. So it wouldn't even be timely -- it wouldn't be timely until Wednesday. Now here it is Monday, and they're saying they want to use it. So I object.

THE COURT: Is this it over here?

MR. GEORGE: It is, Your Honor. And with respect to the disclosure, I don't quarrel with Mr. Bullock's statement. The circumstances, just so the court understands, no gamesmanship here, I, candidly, had forgotten about the diorama until Dr. Sullivan showed up with it, and it reminded me that it was something that had been put together.

Again, Your Honor, if the court thinks it would even be mildly useful, we're happy to use it. We think it would be slightly helpful, but if the court has reservations or is sensitive to Mr. Bullock's concern, we understand that, too.

With respect to the disclosure issue, candidly, Your Honor, it's not that difficult to look at the model and understand it. So I don't think there's any prejudice.

THE COURT: With all due respect, I just don't think it's going to be helpful. Is there anything special about it that would -- I grew up, as you know, partially on a farm, not a big farm, but, look, I don't know that it's going to be helpful to the finder of fact.

MR. GEORGE: The aspects we wanted to discuss, and that will be shown by the model, is some of the hydrologic considerations with respect

to cattle behavior, areas in pastures that can be hydrologically active and that have unique impact on the water quality aspects of cattle.

THE COURT: We've gone over that here. I'm pretty familiar with it. With all due respect, Mr. Bullock's objection is sustained. Go ahead. I think we can talk about it, but I think we're all familiar with those impacts.

MR. GEORGE: I appreciate that, Your Honor. I'll move to the questions.

Q. (By Mr. George) Doctor, can you provide the court with an explanation as to how cattle grazing can adversely impact water quality in terms of phosphorus?

A. Yes. But it's a pretty complicated issue. There's a lot to it. It mainly has to do with the water flows, where the water moves, and the behavior of the cattle.

So let's start with the behavior of the cattle. So when cattle have access to streams, they tend to spend a disproportionate amount of time in and around those streams. And when cattle deposit their feces in the stream, that's obviously a direct source of phosphorus to the stream.

Also, when they deposit their feces in the

riparian area and in areas that are close to the stream, there's an increased likelihood that these feces will be deposited on land that is hydrologically active, because the land in close proximity to a stream has a higher probability of being hydrologically active than does land further upslope. Frankly, that's the reason for the regulations that say don't spread litter close to streams.

And so the fact that the cattle have access to those areas to deposit their feces in locations that are more likely to be hydrologically active and that they disturb the soil in those areas, too, both of those things are going to promote the transport of phosphorus from erosional sources and from cattle to the stream.

Q. Let me interrupt you, Doctor, and ask you a question. What do you mean by "hydrologically active"?

A. Hydrologically active areas are the areas that are prone to contribute overland flow. And I guess maybe if we haven't heard much about this in the proceedings, I would need to back up and describe the different types of flow and what overland flow is. Is that appropriate?

Q. Sure. Let's take it stepwise, if we can, and let me interject some questions as we go so we can break this up.

Can you provide the court with your definition of overland flow.

A. Overland flow is, when it rains, water flow from the rain going over the surface of the ground. So in the case of pastures at issue here, it would be water flowing over the pasture surface during that rainstorm.

Q. Okay. Are there different types of overland flow?

A. Yes. There are two primary types of overland flow. They're similar that in both cases, what's causing it is that the spaces between the soil particles are full of water, and so when additional water comes along from rainfall, it can't go down into the soil, it can't infiltrate because the spaces are already full. That's why it flows over the surface. Otherwise, in most soil types, it would -- excluding clay -- but in most soil types, it would tend to infiltrate down into the soil.

But if the spaces are full, it can't and, therefore, it's got to go somewhere. It's going to follow gravity, and that's overland flow.

But there are different things that cause the spaces to be full. One is that it's raining so hard that the rate of rain exceeds the rate of infiltration that the soil are capable of.

Q. What's that called?

A. I'm sorry, what?

Q. Is there a particular term or phrase to describe that?

A. Yes. That's called infiltration excess overland flow. It's also called Hortonian overland flow, H-O-R-T-O-N-I-A-N, named after a hydrologist named Horton that described this process. So that's one type of overland flow.

Q. What's another type?

A. Another type is what's called saturation excess overland flow. And what causes that is that if the water that's flowing through the soil flows to these relatively lower elevations in the watershed and fills up those soil spaces, then that water table is going to rise and, in some cases, go all the way up to the surface of the ground.

It's a phenomenon associated with a rising water table, coupled with flow down in the soil profile itself, which is called interflow. And that combination of water building up typically in areas

closer to a stream, if the water table comes to the surface, then you've got that same situation again where when more rain comes down, it has nowhere to go. It can't infiltrate into the soil because the spaces are filled with water. Therefore, it's going to follow gravity and go over the surface.

The reason this is important is because overland flow is very well known and recognized to be the principal vehicle for transporting a lot of nonpoint source pollutants, including from pastureland and including the pollutant phosphorus.

Q. How can cattle impact overland flow?

A. Cattle can impact overland flow because the amount of vegetation, the density and the health and vitality of the vegetation has a large influence on the rate of infiltration of rainfall into the soil.

So if you have a good stand of vegetation, grasses, hedges, shrubs, trees, whatever, you've got a good stand of vegetation, it provides opportunity for that rainfall to move down into the soil.

When you remove that vegetation -- so this is -- it happens gradually as you degrade the vegetation, but it's especially pronounced when you have bare soil. The bare soil crush over at the top. You don't have the roots providing avenues for

water movement, and you get a dramatically reduced amount of infiltration when it rains. So you're promoting the occurrence of overland flow that otherwise would not happen there.

And that vegetative cover is an important parameter that's used in evaluating phosphorus indices and all of these things. That's why, is because of its influence on infiltration.

Well, the cattle will trample and eat and otherwise destroy the vegetation in the areas where they concentrate, and those areas are often very much associated with the riparian zone around the streams.

So when you damage vegetation and when you remove the vegetation near the streams, you're further increasing that overland flow in a situation with that very close proximity to the stream. So you put any source of phosphorus there, it is going to be, in many cases, but not always, naturally prone to overland flow anyway. And then you further accentuate that with the behavior of the cattle, and the end result is a much more marked transfer or transport of the constituents, phosphorus, bacteria, whatever you're talking about, into the stream.

Q. Doctor, are you familiar with a term

"channelization" as it relates to cattle behavior in riparian areas?
A. Yes.
Q. For the record, what is that?
A. It's a description of an erosional process that occurs. Cattle, in the areas that they frequent, will tend to follow the same pathways, not always, but often, and those pathways get worn and the vegetation gets degraded or removed. And that encourages erosion when it rains for the reasons that I just talked about, that it crusts over and you don't have the conduits for infiltration.

So that encourages erosion, and as that soil erodes away, you get these little mini canyons across the landscape, and that just further accentuates all of these processes that we're talking about.
Q. Doctor, are you familiar with the term "loafing" as it relates to cattle?
A. Yes.
Q. Is it commonly recognized that cattle tend to loaf in riparian areas?
A. They loaf in areas where they have good access to water and shade, and that's often, but not always, in the riparian areas.

Q. You're familiar with the term "compaction" as it relates to cattle behavior?
A. Yes.
Q. What is compaction?
A. They're pretty heavy animals, and that weight is distributed across relatively small feet, and so the soils get compacted, coupled with the destruction of the vegetation, and that compaction makes the soils less pervious. They're becoming more like the impervious land that we talked about in the urban areas, although certainly not to that extent. It's another process that favors overland flow of water and, therefore, overland transport of whatever is available to that water.
Q. Doctor, the State's experts have testified that the potential impact of cattle on water quality can be discounted because cattle are simply recyclers of nutrients. Do you agree with that?
A. Well, I certainly agree --
MR. BULLOCK: Objection, Your Honor, I don't believe there was anything in his opinions concerning recycling.
MR. GEORGE: He's commenting on testimony that has been provided in this trial.
MR. BULLOCK: That same testimony was in

the expert reports to which Dr. Sullivan should have responded to if he had an opinion relative to it.

MR. GEORGE: Your Honor, I'm told that the recycling discussion is, in fact, in Dr. Sullivan's expert report.

MR. BULLOCK: Where, and I'll withdraw my objection?

MR. GEORGE: Page 96. If Mr. Bullock is not satisfied, I'll provide you a copy. You may have a copy of his report, Your Honor.

MR. BULLOCK: I forgot about it, Judge. I withdraw my objection.

THE COURT: Mr. George.

MR. GEORGE: Thank you, Your Honor. And thank you, Mr. Bullock.

Q. (By Mr. George) The State's experts have testified that the potential impact of cattle on water quality can be discounted because cattle simply recycle nutrients. Do you agree with that?

A. Well, I can't give a yes or no answer to that question, and here's why: When cattle are on the upland pasture away from the stream in areas that are not hydrologically active, they consume forage that contains phosphorus that has been brought up by the plant roots from the soil, and they consume that

forage and they defecate. And that phosphorus is recycling through the system, and the extent to which that phosphorus then is eventually moved back into the soil, then that becomes recycling. So there are certainly situations under which cattle are recycling nutrients. I would not dispute that.

But with respect to the issues at hand in this case, we're concerned about the transfer of phosphorus from pastureland, from whatever source, to a stream. When cattle consume forage in the upland pasture and then they walk down to the stream to drink, to loaf, to -- and then they deposit their feces there, that's not recycling in the pasture. That's a transfer process of taking phosphorus that would otherwise be recycled and moving it to the stream itself when they defecate in the stream or to these areas -- riparian areas that are far more likely to be hydrologically active.

There's no recycling about it in that case. I mean, you might say relative to the entire watershed, it's still in the watershed. That's absolutely true. But relative to -- we talked about this mass balance on streams versus watersheds. Relative to the stream, that is not recycling at all. That's moving the phosphorus from the upland

pasture to the stream.
Q. Based upon the data that you have reviewed, are cattle a significant enough potential source of phosphorus that they should have been evaluated in this case?
A. Yes.
Q. Did you see any meaningful analysis of phosphorus from cattle in the work of the State's causation experts?
A. No, I didn't.
Q. One last potential source I want to discuss with you, Doctor. To what extent, if any, might people recreating in the Illinois River Watershed impact water quality?
A. I think there's certainly a potential for impact there.
Q. Could you explain that potential, please.
A. Well, there are a lot of people that recreate in the Illinois River Watershed. I mean, I observed that when I was there myself. And I read Dr. Caneday's report, and he talked about millions of visitors to the watershed and he talked about some 150-odd (sic) floaters on the river per year, I believe, was the figure, as I remember.
And there has been mention in past

management reports and whatnot for the IRW that there are inadequate restroom facilities available, and that was my impression when I canoed as well, that it could be rather difficult to find a restroom.

And it's a very heavily used recreation area for families. I know what it's like to recreate in the outdoors with children, and I think that that's -- I don't know how big of an impact it would be, but I think it's something that should have been evaluated.

Q. Did you see any evaluation or analysis of the impact of recreators on water quality by any of the State's experts?

A. No.

MR. GEORGE: Your Honor, this is a transition point for me. I realize we are still a few minutes before five.

THE COURT: Mr. Bullock, do you care to begin tomorrow morning?

MR. BULLOCK: I think that would be best.

THE COURT: Let's do that. We'll be in recess until then.

(Recess was had.)

REPORTER'S CERTIFICATE

I CERTIFY THAT THE FOREGOING IS A TRUE AND CORRECT TRANSCRIPT OF THE PROCEEDINGS IN THE ABOVE-ENTITLED MATTER.

S/Terri Beeler
Terri Beeler, RMR, FCRR
United States Court Reporter